Instruments

THE MAGAZINE OF

Measurement and Control

FEB. 1945

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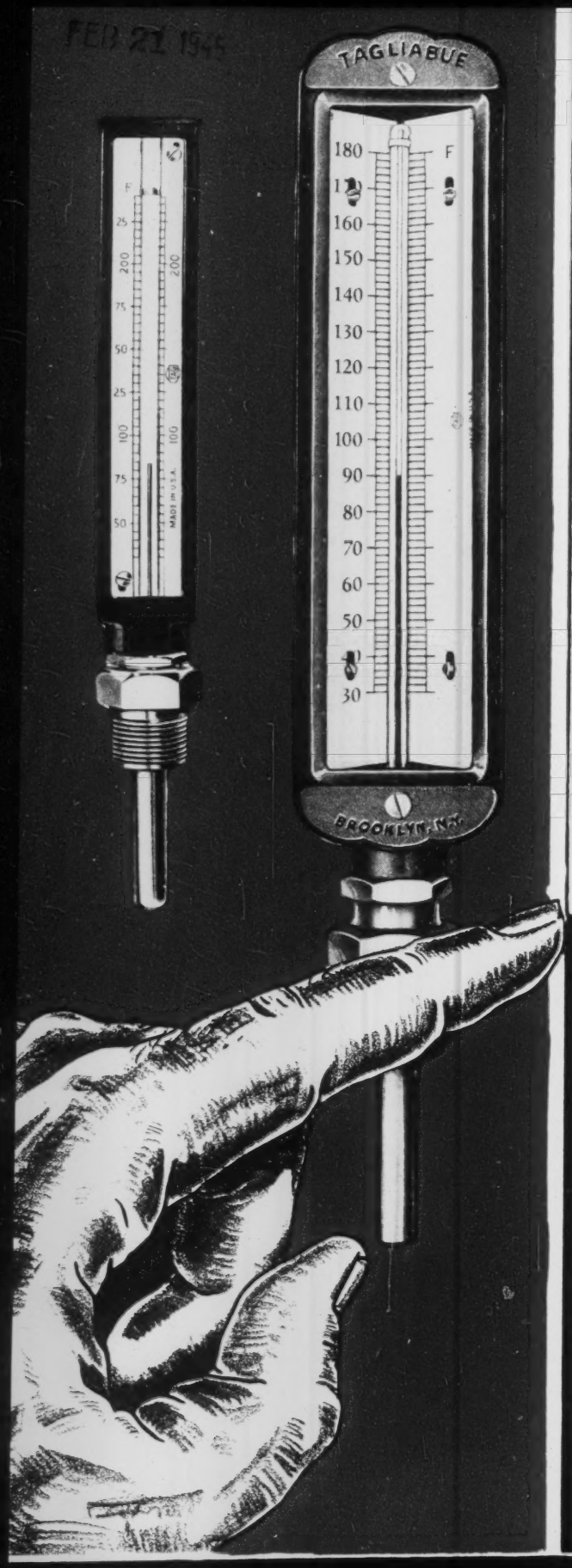

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Combined with

PERMANENT ACCURACY

are characteristics of any good thermometer, but...

TAGLIABUE THERMOMETERS

are more than just good thermometers. They are backed by an enviable reputation built up through years of service.

PORTABLE PRODUCTS CORPORATION

C.J. TAGLIABUE DIVISION

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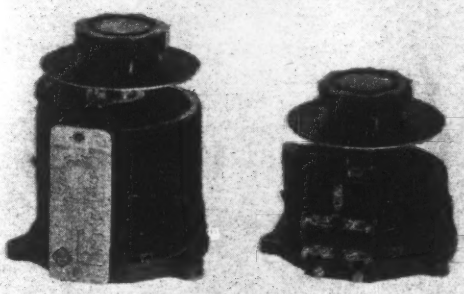
Instruments for Indicating, Recording and Controlling

PARK & NOSTRAND AVES., BROOKLYN 5, N.Y.

A NEW VARIAC FOR 400 TO 2600 CYCLES

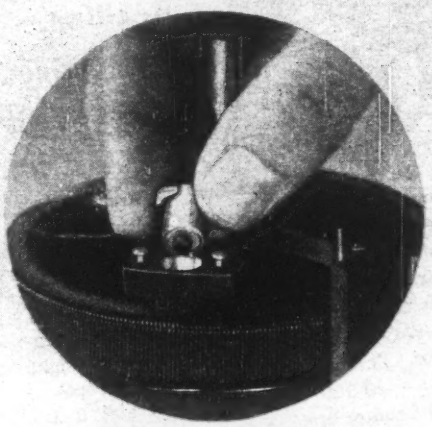


200-CU 60 ~ NEW 60-AU 400-2600 ~
SAME POWER RATING

DESIGNED for an increasing number of applications requiring the control of power at frequencies higher than 60 cycles, this new VARIAC meets the need for a unit for frequencies between 400 and 2600 cycles. It is a companion to the widely used Type 200-A having substantially the same power rating . . . 860 va; with a load current of 5 amperes, rated, and a maximum current of 7.5 amperes near zero and line voltages.

A number of new mechanical features are incorporated in the Type 60-A VARIAC. Included are:

- New unit brush construction requiring no tools for brush replacement and designed to prevent contact between brush holder and winding when the brush wears away
- Positive rotor contact with NO pigtail
- Combination screw and solder terminals
- Fully insulated hollow steel shaft
- Improved bearings, suitable for motor drive

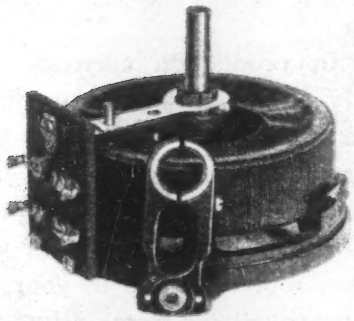


UNIT BRUSH — REPLACED IN A FEW SECONDS

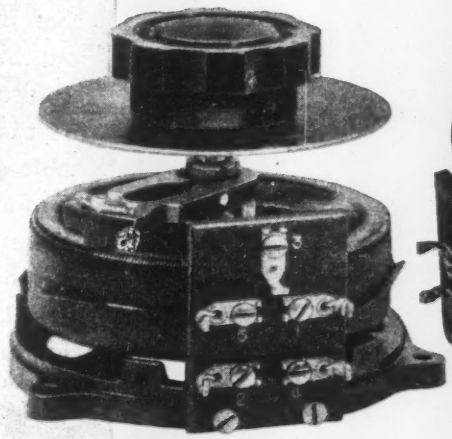
As seen in the photograph, the Type 60-A VARIAC is considerably smaller than its 60-cycle counterpart. The Type 60-AU is priced at $13.00 and the 60-AM at $15.00.

Because all VARIAC production is scheduled months in advance on high priority war orders for 60-cycle models, these new VARIACS are now available only in sample quantities.

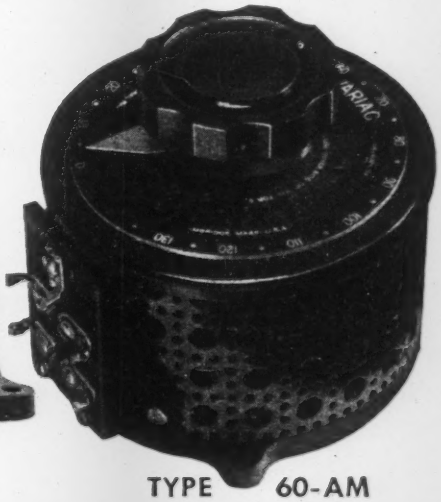
● **WRITE FOR BULLETIN 922**



POSITIVE ROTOR CONTACT WITH NO PIGTAILS



TYPE 60-AU



TYPE 60-AM

VARIAC

MADE ONLY BY

GENERAL RADIO COMPANY

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NEW YORK
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Simplify TEST PROCEDURE

with these versatile WESTON Test Instruments

The Multi-Purpose, Super-Sensitive Analyzer

(MODEL 772)

A compact and practical wide-purpose instrument with sensitivity of 20,000 ohms per volt, or 1000 ohms per volt, on dc ranges.

Ranges – all self-contained

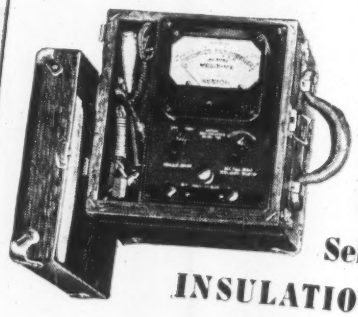
Voltage, a-c and d-c – 0-10-50/250/500/1000 volts.

Current, d-c – 0-10 1 amps. – 0-250/50/10/1 milliamps. and 100 microamps.

Ohms – Full Scale – 30 3 megohms – 30,000/3000 ohms. Center Scale – 250,000/25,000/250/25 ohms.

Decibels – –14 to +2, –2 to +14, +12 to +28, +26 to +42, +38 to +54.

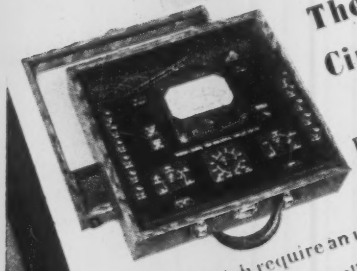
(Voltages up to 5000 dc available through use of external WESTON Televerter, Model 766.)



The Direct-Reading, Self-Contained INSULATION TESTER

(MODEL 796)

This compact direct-reading resistance tester eliminates hand cranking and thus makes leakage testing a simple one-man job especially in unaccessable places. Tests up to 200 megohms at test potential of 350 to 500 volts d-c; although, the current at terminals is only a few microamperes. Operates from long life, light-weight batteries. There are no vibrators to replace. Ranges: 0-20-300 megohms full scale; 0-.5-5 megohms center scale. Size 8″ x 9⅛″ x 8″.



The Industrial Circuit Tester

(MODEL 785)

Recognized as the most complete unit for routine maintenance tests, and for testing needs which require an ultra-sensitive instrument.

Ranges all self-contained

D-C VOLTAGE . . . Six Full Scale Ranges of: 1/10/50/200/500/1000 volts (20,000 Ohms per volt).

A-C VOLTAGE . . . Six Full Scale Ranges of: 5/15/30/150/300/750 (1,000 Ohms per volt).

D-C CURRENT . . . Six Full Scale Ranges of: 50 Microamps . . . 1/10/100 Milliamps. . . . 1/10 Amps. (Higher ranges, at half scale reading, with 100 mv. external shunts).

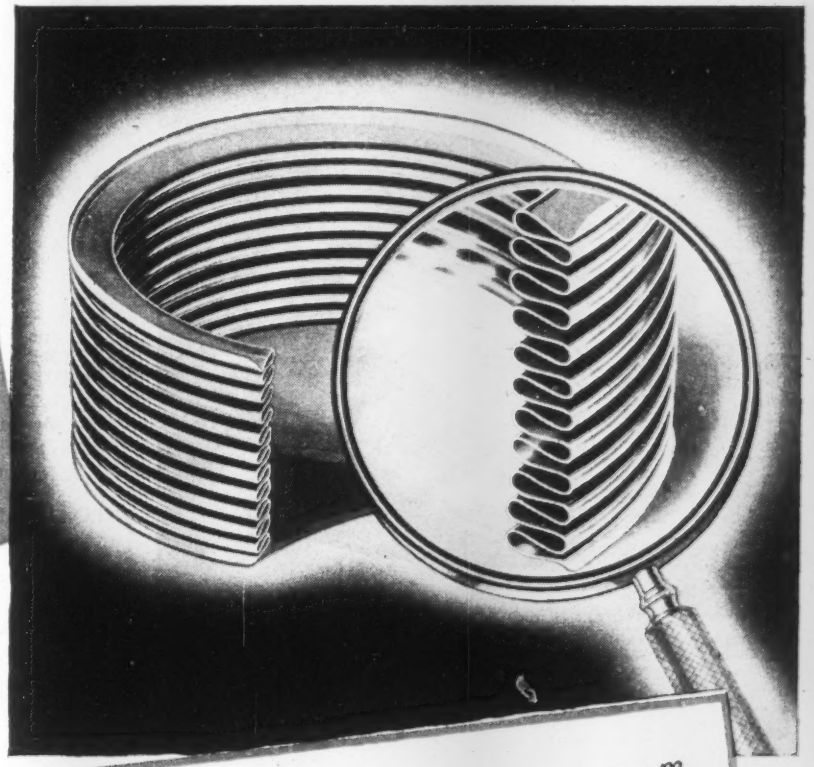
A-C CURRENT . . . Four Full Scale Ranges of: .5 1/5/10 Amperes. (Higher Ranges with external current Transformers.)

RESISTANCE . . . Five Full Scale Ranges of: 3,000/30,000/300,000 Ohms . . . 3/30 Megohms. Center Scale Values . . . 25/250/2,500/25,000/250,000 Ohms. (Self-Contained Batteries)

With production currently running slightly ahead of war requirements, a limited number of the popular WESTON test instruments shown herewith are available and are offered subject to prior sale. Orders can be placed direct, or with the WESTON representative in your vicinity. Literature available from…WESTON Electrical Instrument Corporation, 591 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON
INSTRUMENTS

Question: How long will it last?



ANSWER:

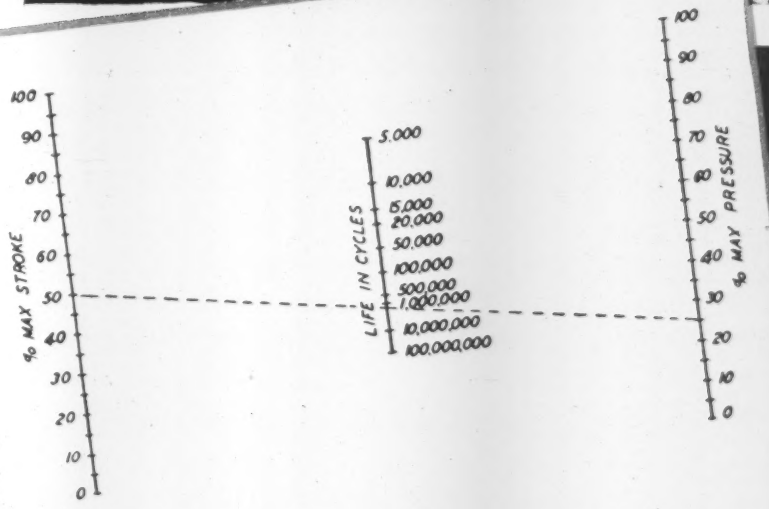
Using a straight edge, connect the stroke expressed in percentage of the maximum stroke and the pressure expressed in the percentage of the maximum pressure. This line intersects the central scale at the probable life.

Example: A 1½" O.D. bellows (listed on page 11, line 56) having 14 active convolutions, is to operate making 0.2051" stroke under 42.5 lbs. per sq. in. pressure. What will be its probable life?

Percent of Maximum Stroke = 50% (0.2051 ÷ 0.4102 = 50%. See columns 4 and 7, page 11).

Percent of Maximum Pressure = 25% (42.5 ÷ 170 = 25%. See column 10, page 11).

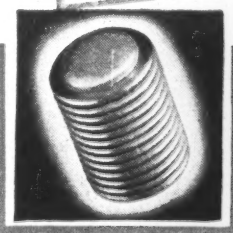
A line connecting 50% stroke and 25% pressure intersects central scale at more than 1,000,000 cycles. This figure is the probable life under the stated conditions.



SERVICE LIFE EXPECTANCY CHART

The chart above shows the relation between stroke, pressure and life. It is based on results of hundreds of tests conducted on various sizes and types of bellows under many different conditions and affords a method of predicting bellows life expectancy.

EXCERPT: Above chart is taken from new Bridgeport Bellows catalog CE-100 This valuable reference book sent upon request. Includes information which should be in every data file.



Bellows Assemblies . . . Bellows . . . Bellows Devices

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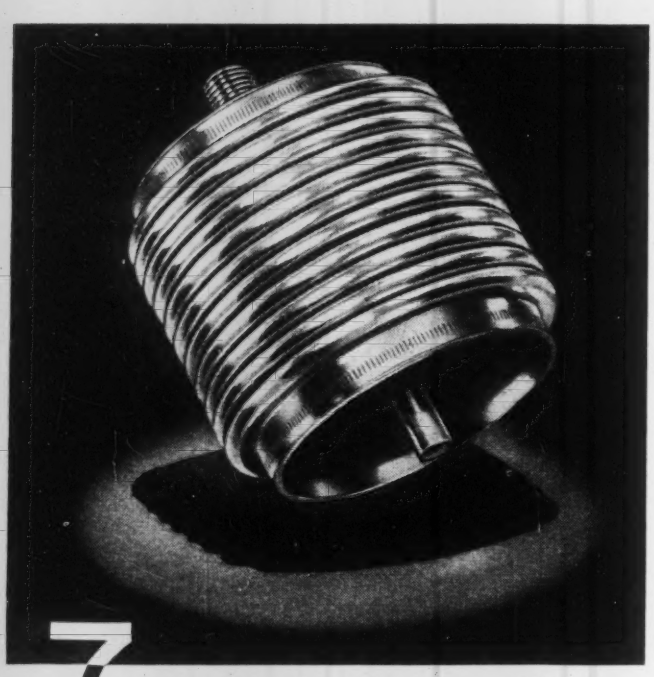

7 Facts You Should Know About C.M.H. *Stainless Steel* BELLOWS

IF YOU PLAN to use bellows for vacuum equipment, thermostats, pressure controls, valves, recording instruments, hydraulic mechanisms, rotating shaft seals, or for other purposes, check these essential features of C.M.H. Stainless Steel BELLOWS.

1. *Corrosion resistant qualities of stainless steel* enable wider application of C.M.H. BELLOWS.
2. *High and low temperatures* do not affect the operating efficiency.
3. *Multiple ply construction* gives even greater strength factors when needed.
4. *Ferrous fittings,* attached by Circular Seam Welding, assure permanent, leakproof joints.
5. *Uni-metal assemblies* avoid the costly troubles encountered where bi-metal types are used.
6. *Long lengths are standard production* permitting economical use of C.M.H. Stainless Steel BELLOWS for many unusual types of applications.
7. *Better delivery schedules* are possible because C.M.H. BELLOWS are standard production products.

Ask for Chicago Metal Hose Form SSB2 on which to submit your bellows requirements. It will save you time—assure more accurate transmittal of essential data.

For complete information about C.M.H. Stainless Steel BELLOWS and about the many types of Flexible Metal Hose in the complete C.M.H. line, write us today.

ARMY E NAVY Flexible Metal Hose for Every Industrial Use

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Instruments

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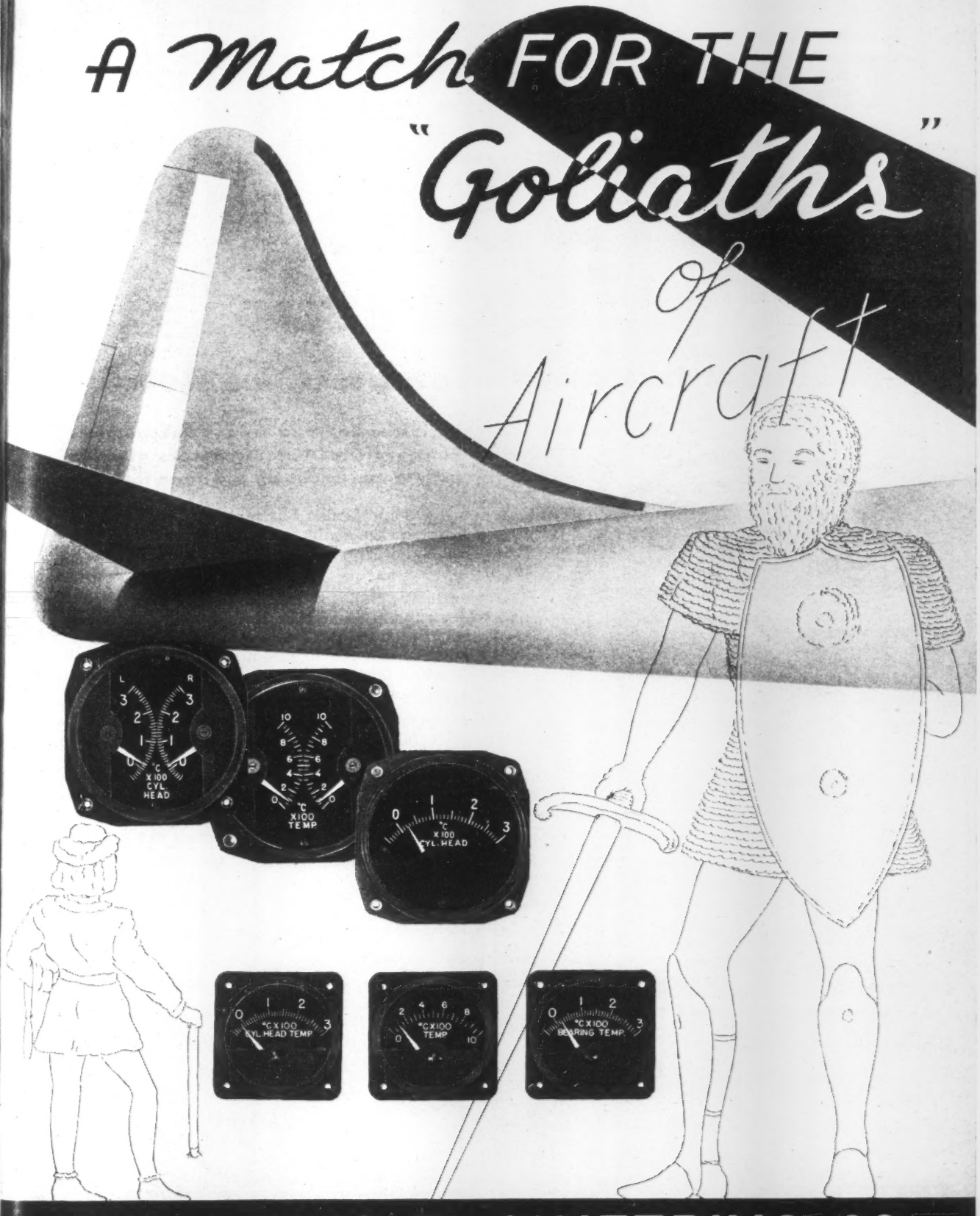
A Match FOR THE "Goliaths" of Aircraft



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Specialists in Engine Temperature Measurements

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TAKE A TIP.....

NOT A TAP...

to get instant, accurate Temperature Readings!

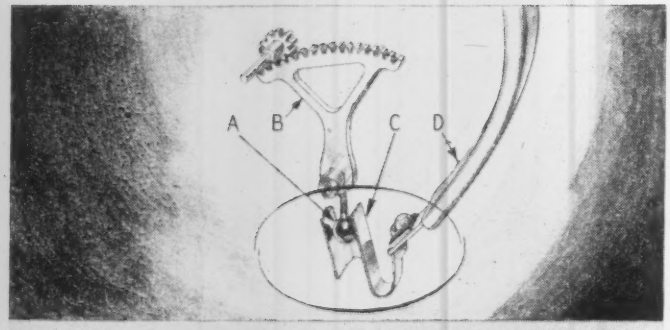
Exclusive Ball-and-Trough linkage gives Foxboro Dial Thermometers positive pointer movement, up and down the scale

When the pointer on a Foxboro Dial Thermometer points to any figure on the scale, *it always means just what it says.* And it takes no tapping of the dial face to make it tell the truth!

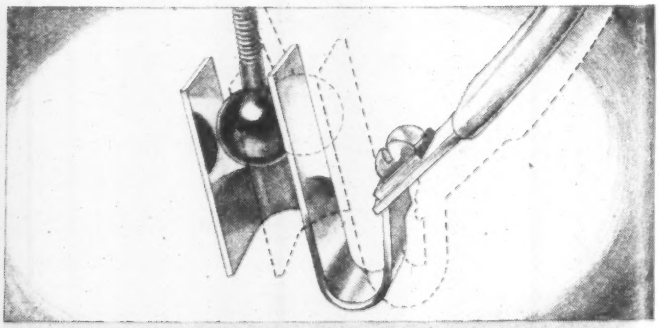
The exclusive Ball-and-Trough linkage in this better-engineered instrument eliminates lost motion . . . insures positive positioning of the pointer, no matter which way temperatures move. What's more, it also eliminates all the angularity errors of lever-type linkages . . . gives uniform, accurate calibration over the entire scale!

Add to this *inherent* accuracy, the *accuracy-in-use* features of Foxboro Dial Thermometers: rugged, all-metal construction — accessible mounting of the indicator anywhere up to 200 feet from the bulb — airplane-type dials that can be accurately read from a distance of 20 feet. You get a lot of extra value, at no extra cost!

Write for full details in Bulletin 148-7. **The Foxboro Co., 46 Neponset Avenue, Foxboro, Massachusetts.** Branches in principal cities.



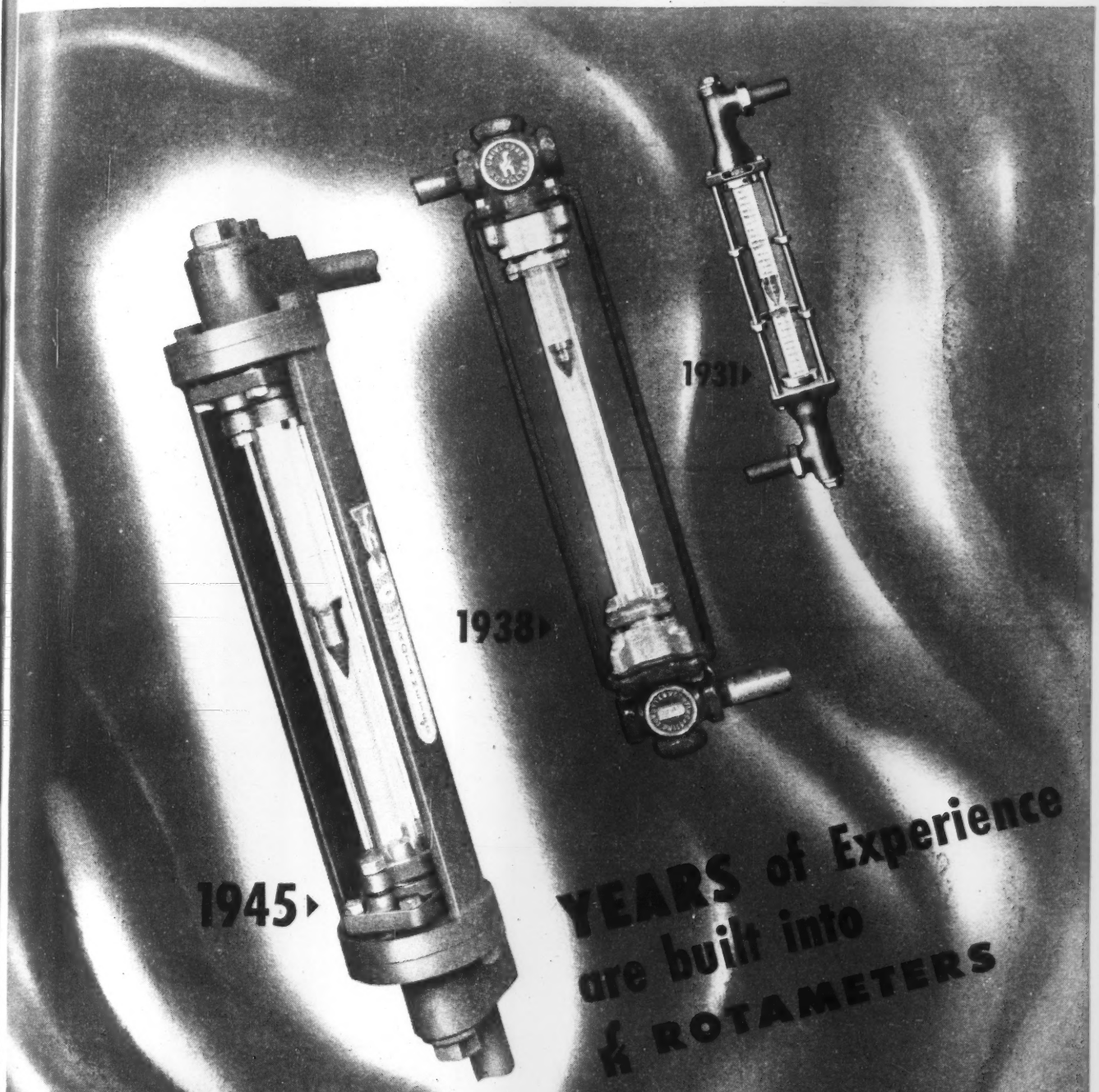
Circled is the exclusive Foxboro Ball-and-Trough linkage. A stainless steel ball (A) integrally connected with the gear segment (B) slides, practically without friction, in a chromium-plated trough (C) attached to the Bourdon Tube (D).



Enlarged view of Foxboro Ball-and-Trough. Dotted lines show typical change in position corresponding with change in temperature. This linkage provides constant, tangential point-contact . . . eliminates lost motion and angularity errors.

FOXBORO DIAL THERMOMETERS

REG. U. S. PAT. OFF.



Tangible evidence of long experience with practical flow-measurement installations are reflected in SK Rotameter design. For instance, the rigid frame carries all of the pipe line stress and the tapered glass tube none. The tube assembly is easily removed without disturbing any pipe connections, and as a result of our experience in designing practical industrial equipment for corrosive service, packing glands have cap-screw adjustment. There are no large, open threads to corrode and "freeze."

The introduction to this country of a method for mass production of interchangeable precision tapered glass tubes is another SK contribution which, with other SK developments, largely accounts for today's wide industrial use of Rotameters. Behind these developments, of course, is the wealth of theoretical and practical knowledge in the science of flow measurement which has been accumulated by SK engineers throughout the years.

Take advantage of this engineering "know-how." As a starting point for the solution of your rate-of-flow problems, write for an SK Rotameter Survey Sheet on which to tabulate information necessary for selecting the proper Rotameter to meet your needs. An illustrated folder describing SK Universal Rotameters will be included.

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Manufacturing Engineers

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Hydrometers are standard in the streamlined "Easy-kleen" pattern which permits instrument to sink rapidly to its floating point, and makes cleaning a simple process. Most of the hydrometers listed have Permax enameled flat metal scales which give three times the angle of vision of conventional paper-scale hydrometers. Furthermore it cannot slip, being firmly anchored in alloy weighting material. Excellent for temperatures up to 285°F.

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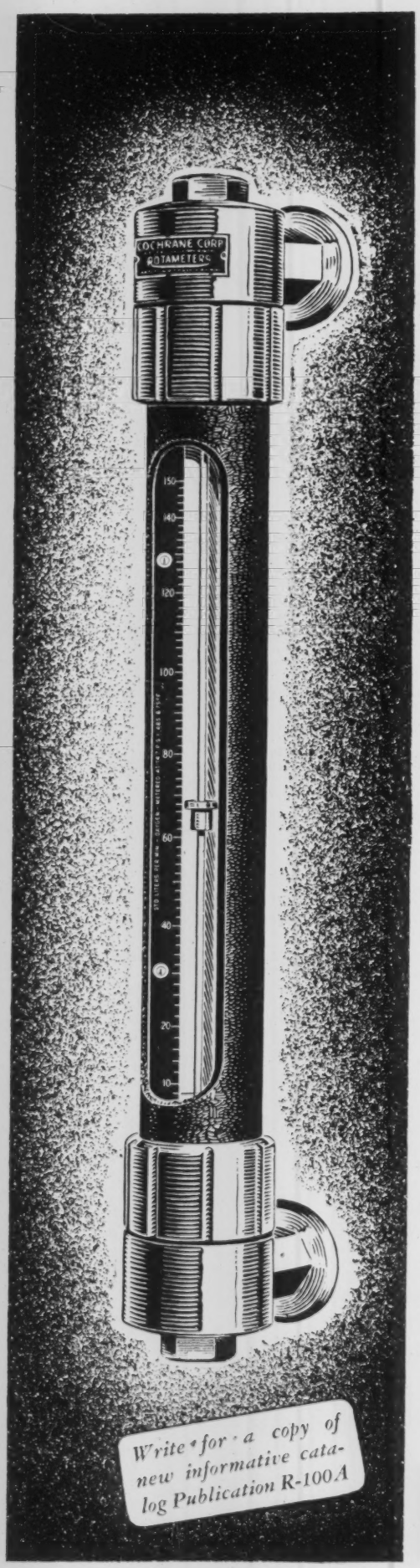

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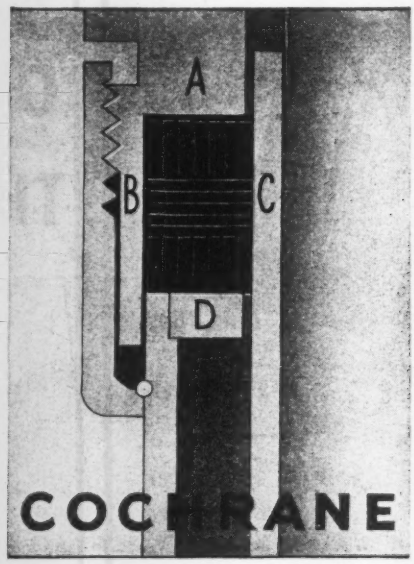
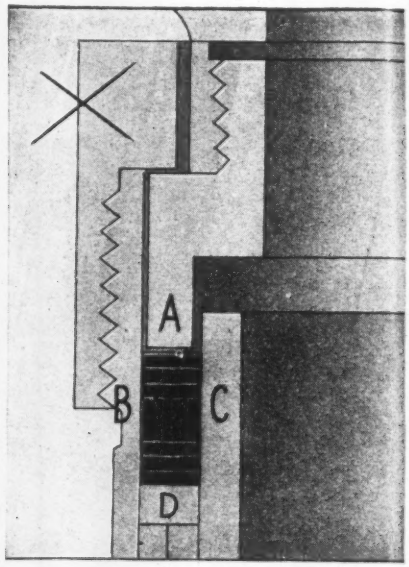




BETTER STUFFING BOX DESIGN

Like all the other points of advanced design in the Series 100 Rotameters, the construction of the stuffing boxes was not patterned after existing design but was carefully studied to insure positive leak-proof performance even when metering corrosive fluids under high pressure. Study of the two stuffing box designs shown above will illustrate this. In both designs, pressure on the packing is exerted at A as the fitting is screwed tight and, because the packing is solidly backed up at D, the pressure is distributed evenly over areas B and C. The most effective sealing is accomplished by the long cylindrical seals of B and C because of their greater surface.

If the sealing action at A would alone be sufficient a simple ring gasket would serve the purpose. Leakage along C is safeguarded in both designs but when the fluid gets past A, the ordinary case-type rotameter shown at the right will leak, because seal B is in no way effective; the leaking fluid will find outlet through the clearanced metal-to-metal joints and threads above it. With the Cochrane construction, shown at left, similar passage of fluid across A produces no leak because the whole surface of sealing face B must be traversed by the fluid before it can get out. Cochrane design is a *real* stuffing box.

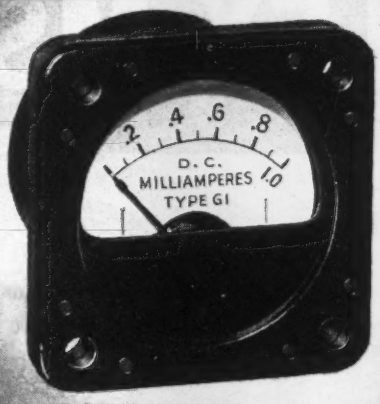
Other Exclusive Features of SERIES 100 ROTAMETERS:

No Damaged Floats (*Spring Float Stops*)
Guide Rod Centered in Metering Tube
Easy Adjustment of Stuffing Boxes
Easy to Change from One Service to Another (*Interchangeable Tubes*)
Easy to Read (*White Backed Tube*)

COCHRANE CORPORATION, 3120 N. 17th St., Phila. 32, Pa.

COCHRANE-ROTAMETERS INC

ROTAMETERS



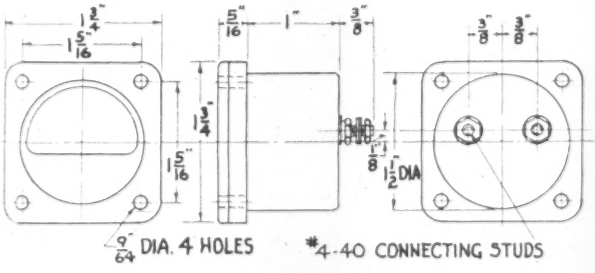
SMALL BUT STURDY...

The New Line of ROLLER-SMITH 1½" Panel Instruments

Design and development of this line of 1½" instruments were based on rigid U. S. Army Air Force specifications. They are built to withstand extreme conditions of temperature, humidity, vibration and shock, and immersion tests have demonstrated their ability to withstand a hydrostatic pressure of 14.7 psi.

Roller-Smith 1½" instruments are now available in d-c voltmeters, 1000 ohms per volt, in all practical ranges above 50 millivolts; d-c ammeters in all practical ranges above 500 microamperes. For certain applications instruments can be supplied with ranges below those specified. Correspondence is invited.

When desired, solder lugs can be furnished instead of the connecting studs shown.



ROLLER SMITH

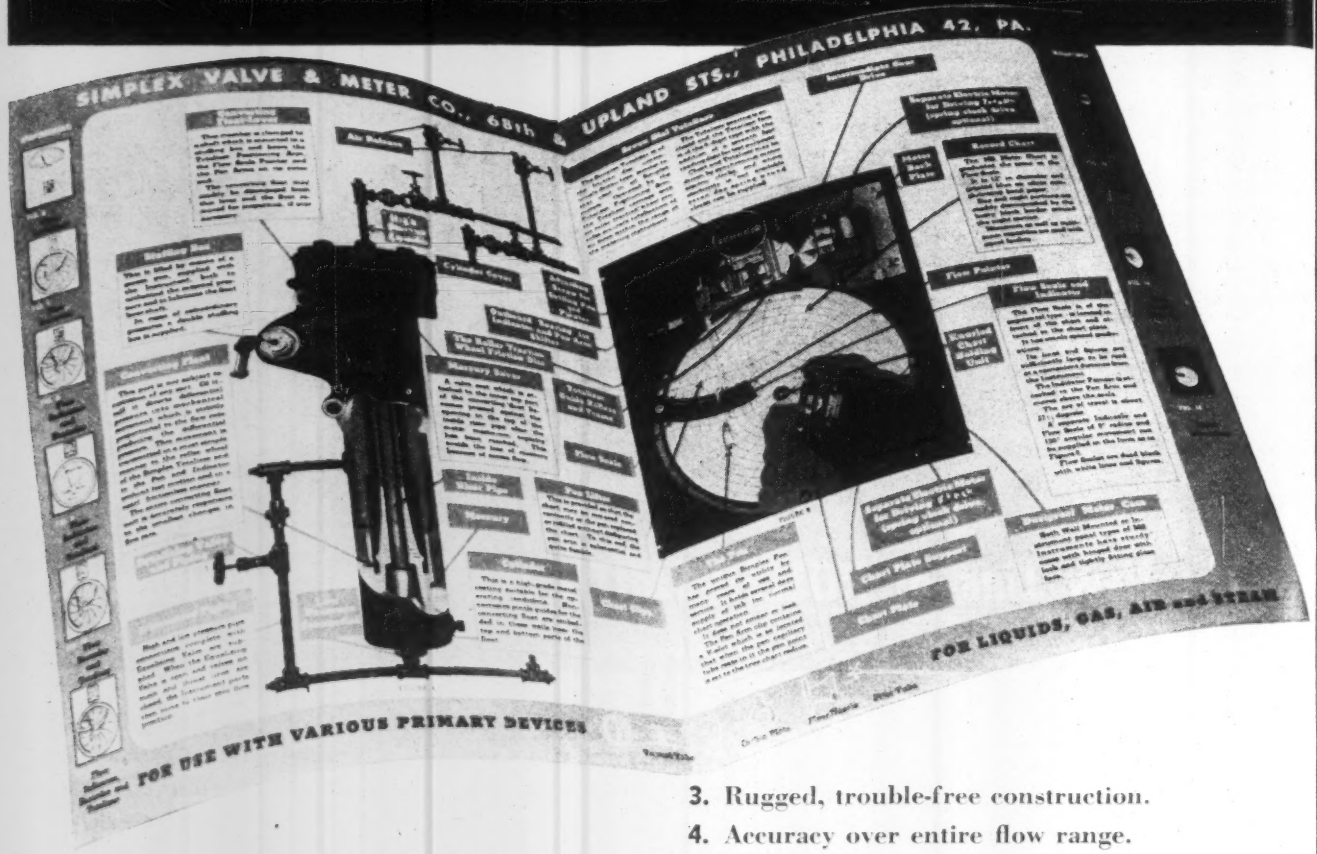
Sales Representatives In all Principal Cities

ROLLER-SMITH BETHLEHEM, PENNA.

Canadian Plant: ROLLER-SMITH MARSLAND LTD., Kitchener, Ontario

STANDARD AND PRECISION ELECTRICAL INSTRUMENTS • AIRCRAFT INSTRUMENTS • SWITCHGEAR • AIR AND OIL CIRCUIT BREAKERS • ROTARY SWITCHES • RELAYS • PRECISION BALANCES

ACCURATE FLOW MEASUREMENT at LOW COST THE SIMPLEX MS METER


SIMPLEX VALVE & METER CO., 68th & UPLAND STS., PHILADELPHIA 42, PA.
FOR USE WITH VARIOUS PRIMARY DEVICES
FOR LIQUIDS, GAS, AIR and STEAM

This low cost Simplex instrument meets the high standards for accuracy, sensitivity and dependability required in measuring flow rates in water and sewage, as well as in power and process plants.

These are some of the advantages of the Simplex MS Meter:

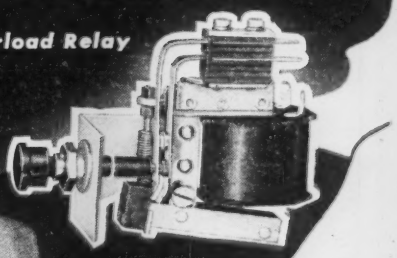
1. Operates efficiently with any suitable primary device.
2. Is installed and maintained economically.
3. Rugged, trouble-free construction.
4. Accuracy over entire flow range.
5. Simplex bell-shaped float which translates the half power of the differential into uniform graduations of chart and dial.
6. Direct reading totalizer of the 7 digit type.

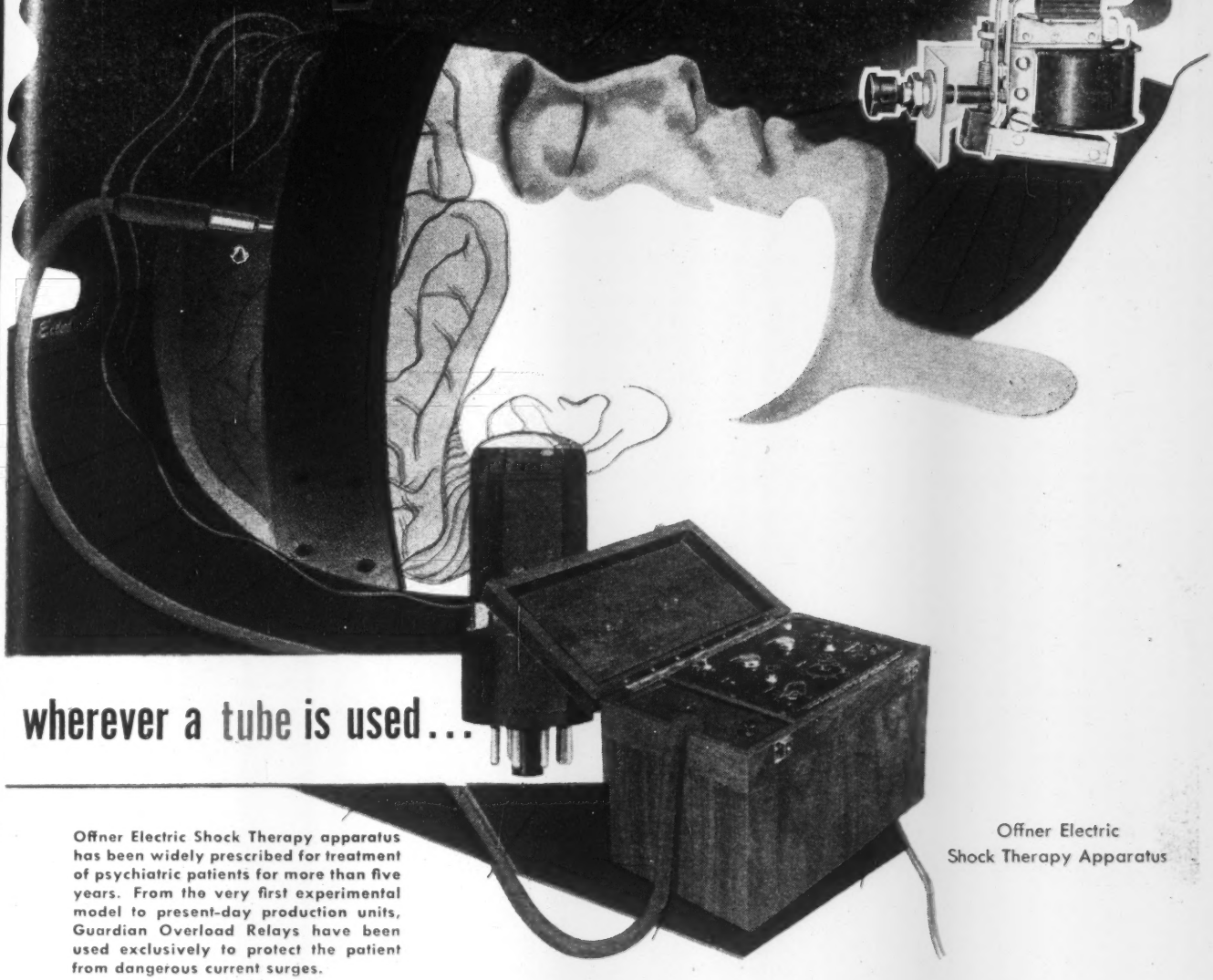
Complete data is now available in Bulletin 350 — straight-forward, factual information with drawings, charts, and test data. Write for your copy today — specify the Simplex MS Meter in tomorrow's planning.

SIMPLEX VALVE & METER CO.
6786 UPLAND STREET, PHILADELPHIA 42, PENNA.

relays FOR OVERLOAD PROTECTION IN ELECTRIC SHOCK TREATMENTS

Series L Overload Relay





wherever a tube is used...

Offner Electric Shock Therapy apparatus has been widely prescribed for treatment of psychiatric patients for more than five years. From the very first experimental model to present-day production units, Guardian Overload Relays have been used exclusively to protect the patient from dangerous current surges.

Offner Electric
Shock Therapy Apparatus

Relays BY GUARDIAN

In certain types of mental disorders it is possible to shock patients back to normal by passing an electric current through brain tissues. Naturally the patient must be protected against the possibility of excessive current surges. Such protection must be positive—dependable. In providing this protection, Guardian Series L Overload Relays have established a perfect record for safe, dependable performance in hundreds of thousands of known treatments.

The Series L Overload Relay provides accurate protection against surges and overloads. Standard coils attract on 150, 250, 500, or 750 milliamperes; coils for operation on other current values are available on specification.

The large, oversize contacts used on this relay can take severe overloads without damage. They are rated for 1500 watts on 110 volt non-inductive A.C. and in A.C. primary circuits of any inductive power supply delivering up to and including 1 kilowatt. Contacts lock open and cannot be reset until overload is removed. For further information, write for Series L bulletin.

Consult Guardian whenever a tube is used—however—Relays by Guardian are NOT limited to tube applications, but may be used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

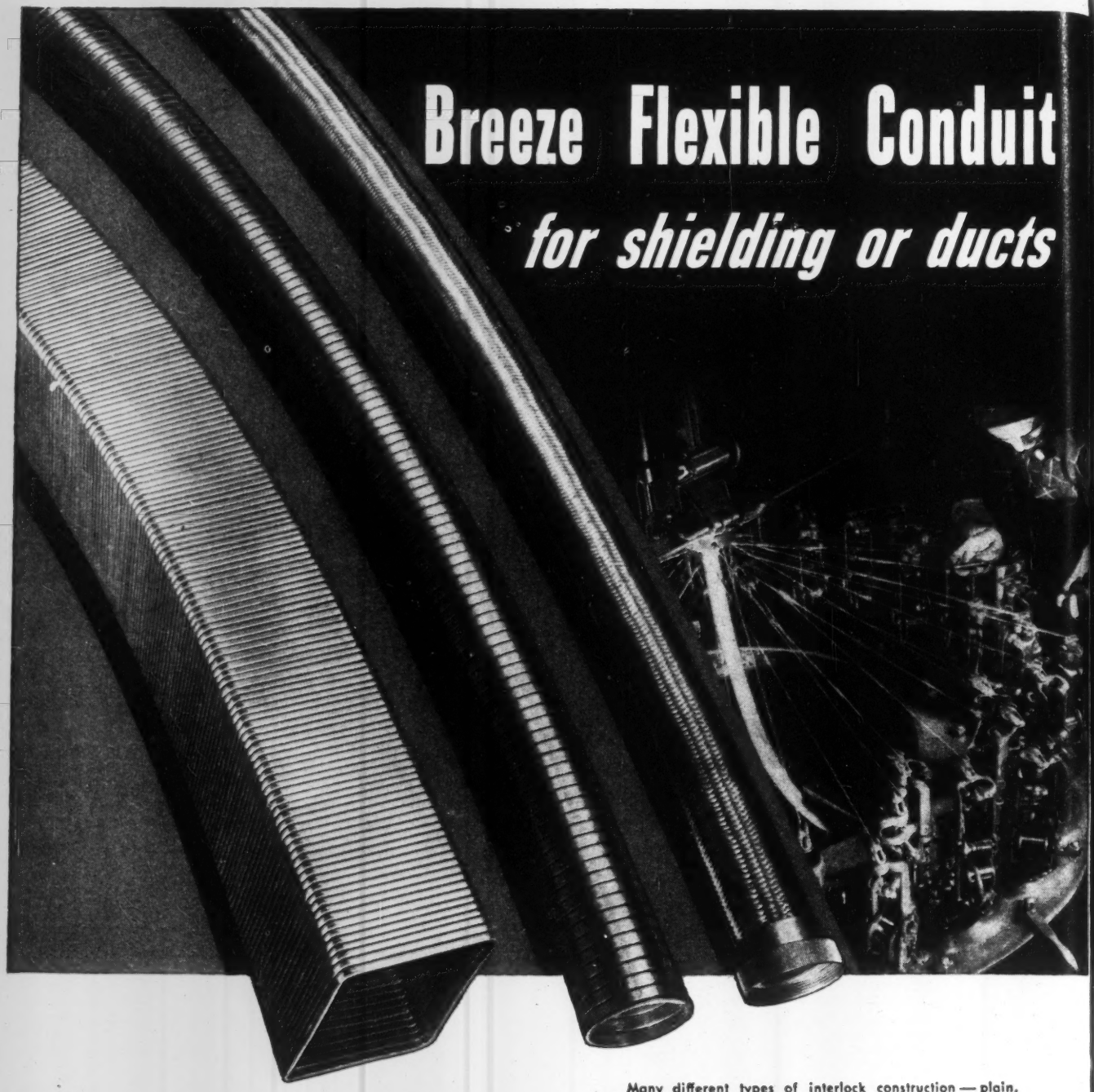
GUARDIAN ELECTRIC

1638-B W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

Breeze Flexible Conduit

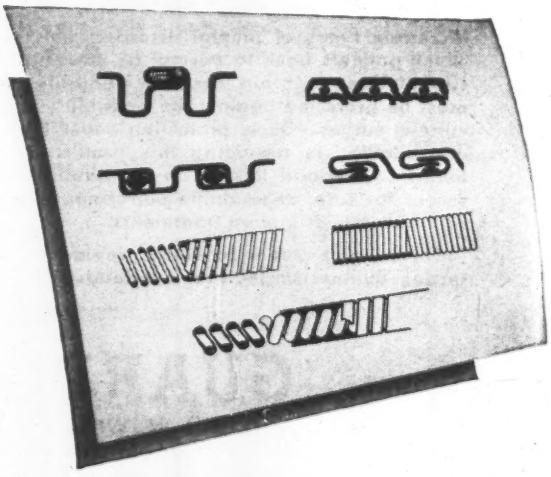
for shielding or ducts



Breeze Flexible Tubing, manufactured in many diameters from a wide variety of metals, is used as ventilation and exhaust ducting in industrial, aircraft, marine and automotive applications. The same basic tubing, with the addition of a braided metal covering, becomes light-weight shielding conduit, used extensively for shielding ignition systems and any electrical circuit to insure dependable radio communication.

Manufactured from a continuous strip of metal, Breeze Flexible Tubing and Conduit can be furnished cut to length, with necessary end-fittings for any conduit installation.

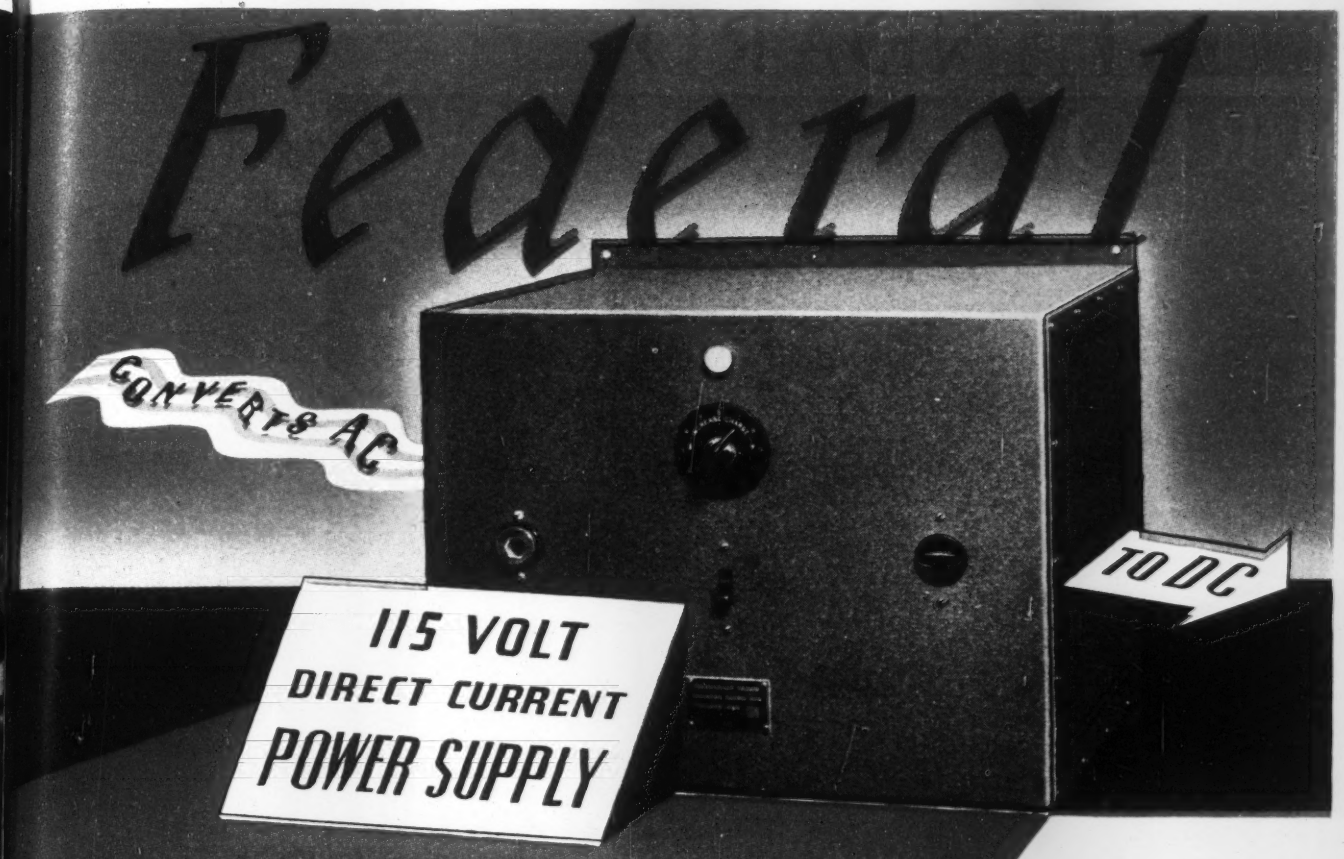
Many different types of interlock construction — plain, packed, and soldered—are available to meet varying use requirements. A few of these are illustrated below.



Breeze BREEZE MARK

CORPORATIONS, INC.

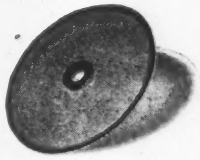
Newark, New Jersey



FEDERAL POWER EQUIPMENT—well known for long dependable life, low cost, and high efficiency . . . made in a wide range of sizes and outputs . . . for any DC need from any AC source.

- **PUBLIC UTILITIES**—for station DC bus service, floating storage batteries and operating controls.
- **CHEMICAL AND METALLURGICAL**—DC power for refining, electroplating, electro-cleaning and laboratory analysis.
- **METALWORKING**—for operating magnetic equipment such as grinders, chucks, lifts and vibrating hammers.
- **FOOD AND DRUGS**—for magnetic separators, operating packaging equipment and power supply for processing.
- **INDUSTRIAL PLANTS**—for DC motor operation, electric brakes, general testing and generator field excitation.

★

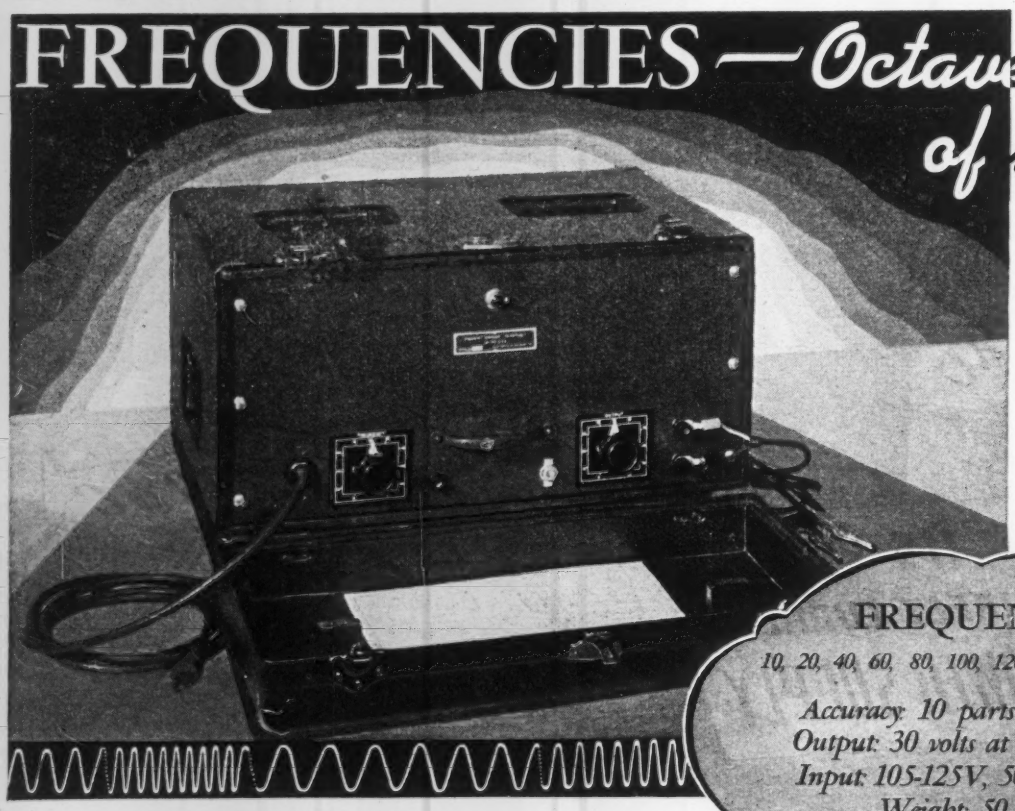


Federal's exclusive CENTER CONTACT Selenium Rectifier discs provide new protection against corrosive atmosphere, are now in Federal Power Supply equipment. FIRST IN THE FIELD . . . STANDARD FOR INDUSTRY. *Write for Bulletins.*

Federal Telephone and Radio Corporation

Newark 1, N. J.

STANDARD FREQUENCIES — Octaves of them



FREQUENCIES

10, 20, 40, 60, 80, 100, 120, 140, 160, 180, 190

Accuracy: 10 parts in 1,000,000
Output: 30 volts at 500,000 ohms
Input: 105-125V, 50-60c., 40 watts
Weight: 50 pounds

Impossible? Well, here it is—

This Multi-frequency generator furnishes the frequencies shown above at the turn of a switch. All frequencies are obtained from a temperature-compensated tuning fork and voltage-stabilized circuit.

With this unit it is possible to calibrate oscillators at many selected points without encountering complex oscilloscope patterns. One of the uncertainties involved in development work on tuned circuits, filters, reeds—and in time measurement can be minimized with the aid of this instrument.

Developed primarily to check frequency meters for precision war work, this Multi-frequency generator possesses a rugged durability and dependability in service that will prove an extra value to many laboratories.

Additional information available on request.

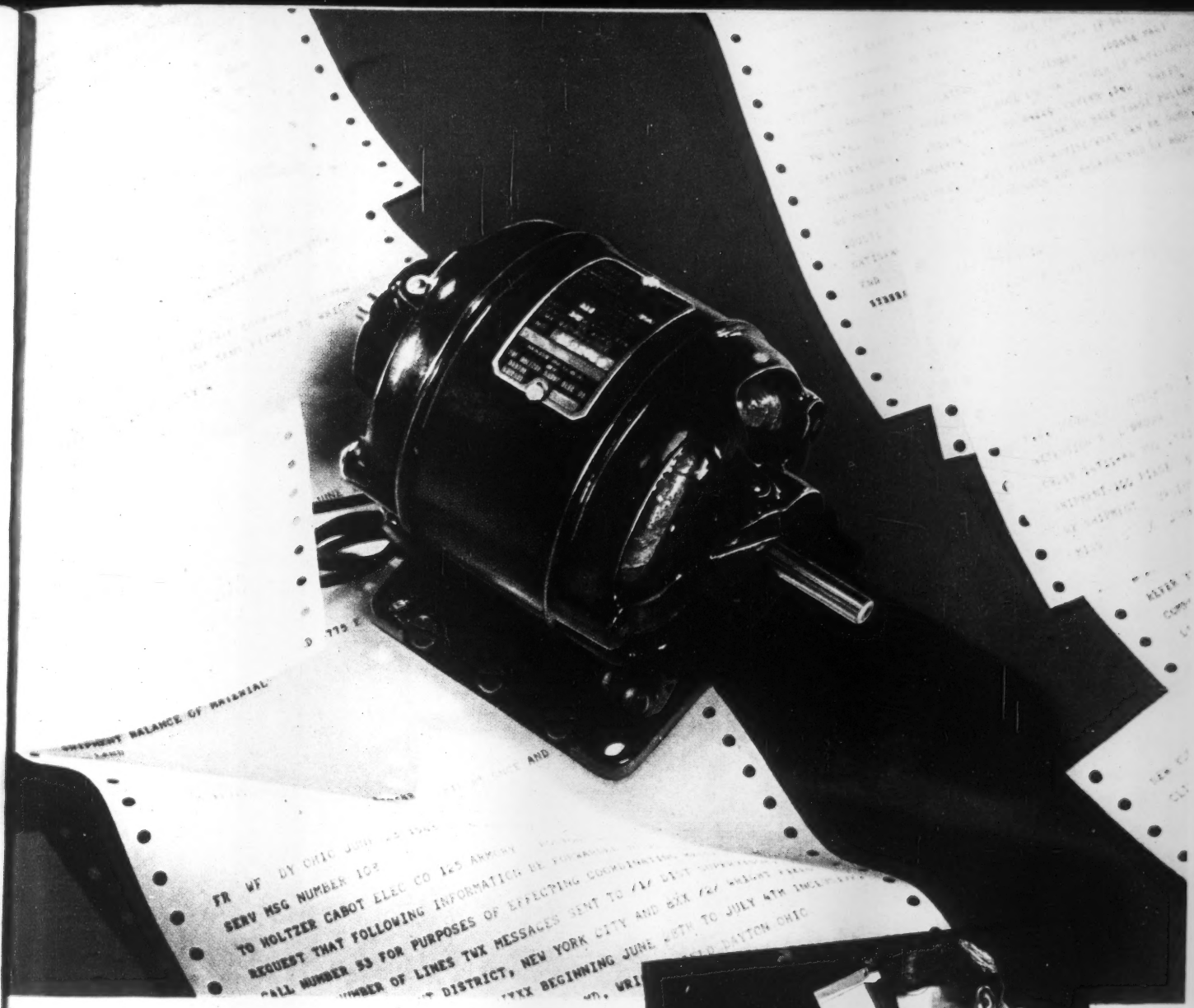
Manufacturer of the

Watch Master

and distributor of
Western Electric
Watch-rate Recorders

American Time Products, INC.

580 Fifth Avenue New York 19, N. Y.



Uniform, Synchronous Speed at Every Station

Teletype Machine powered with a Holtzer-Cabot motor

Electric motors driving the intricate mechanisms of machines that transmit and record messages verbatim must have identical operating characteristics at every station. Since standard "off-the-shelf" motors cannot meet the strict performance requirements, such as uniform, synchronous speed, quietness, load cycles, etc., the solution is a special motor designed to exactly meet the particular operating conditions.

For over 50 years Holtzer-Cabot has designed and built special motors to fit the application. Many machines such as teletype machines, and other sending and receiving equipment are Holtzer-Cabot powered. Although, today, all of our plant facilities are being utilized for building special fractional H.P. motors for military use, our motor development engineers will gladly discuss your post-war motor requirements with you. No obligation of course.

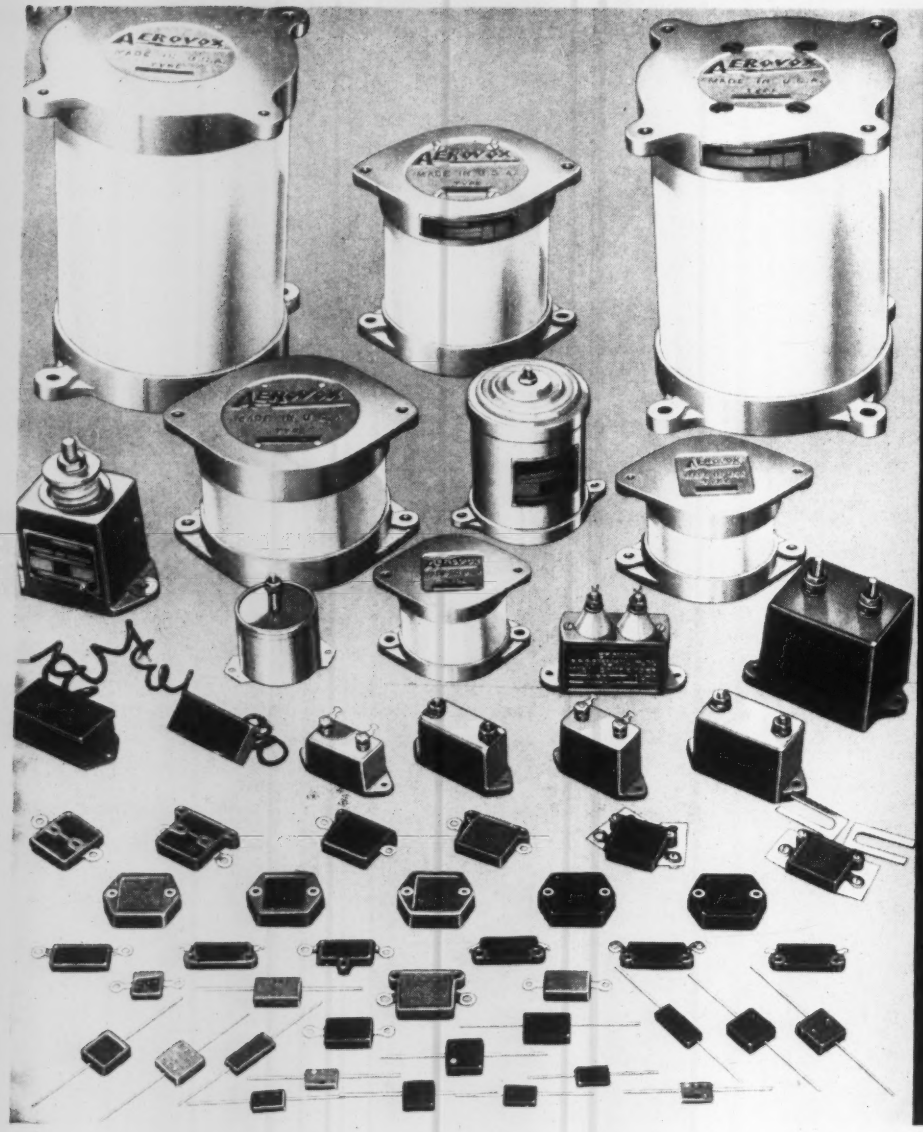
SPECIAL MOTORS DESIGNED TO FIT THE APPLICATION

HOLTZER-CABOT

Division of First Industrial Corporation

Designers and Builders of Special Fractional HP Motors and Electrical Apparatus

125 AMORY STREET, BOSTON 19, MASSACHUSETTS • CHICAGO, ILLINOIS • NEW YORK, NEW YORK • PHILADELPHIA, PENNSYLVANIA



THERE'S A TYPE FITTED *PRECISELY* TO YOUR NEEDS...

AEROVOX MICA *Capacitors*

•

SPECIFY AEROVOX

Be sure you have the Aerovox Capacitor Manual in your working library, for general guidance. And for final insurance covering satisfactory results, just specify Aerovox Capacitors.

● Aerovox selection ranges from tiny "postage-stamp" molded-in-bakelite units to giant porcelain-cased stack-mounting units. These many varied types are standard with Aerovox—in daily production—available at quantity-production prices.

The following factors are suggested in guiding your selection:

Electrical: (a) Capacitance and tolerance; (b) D.C. voltage rating; (c) Current-carrying capacity and frequency characteristics; (d) Allowable temperature rise and maximum operating temperature; (e) Special characteristics such as temperature coefficient, retrace, etc.; (f) Special operating conditions such as high humidity, altitude, extreme temperatures, etc. *Mechanical:* (g) Basic type; (h) Terminals; (i) Case; (j) Mounting holes; (k) Nameplate data.

• • •

Yes, Aerovox expects you to *select* that type best fitting your particular requirements *in every way*. And Aerovox is ready to help you make the proper selection. Remember, *Aerovox Application Engineering*—that "know-how" second to none in the industry—can make all the difference between disastrous makeshifts and the most satisfactory results.

ARMY E NAVY

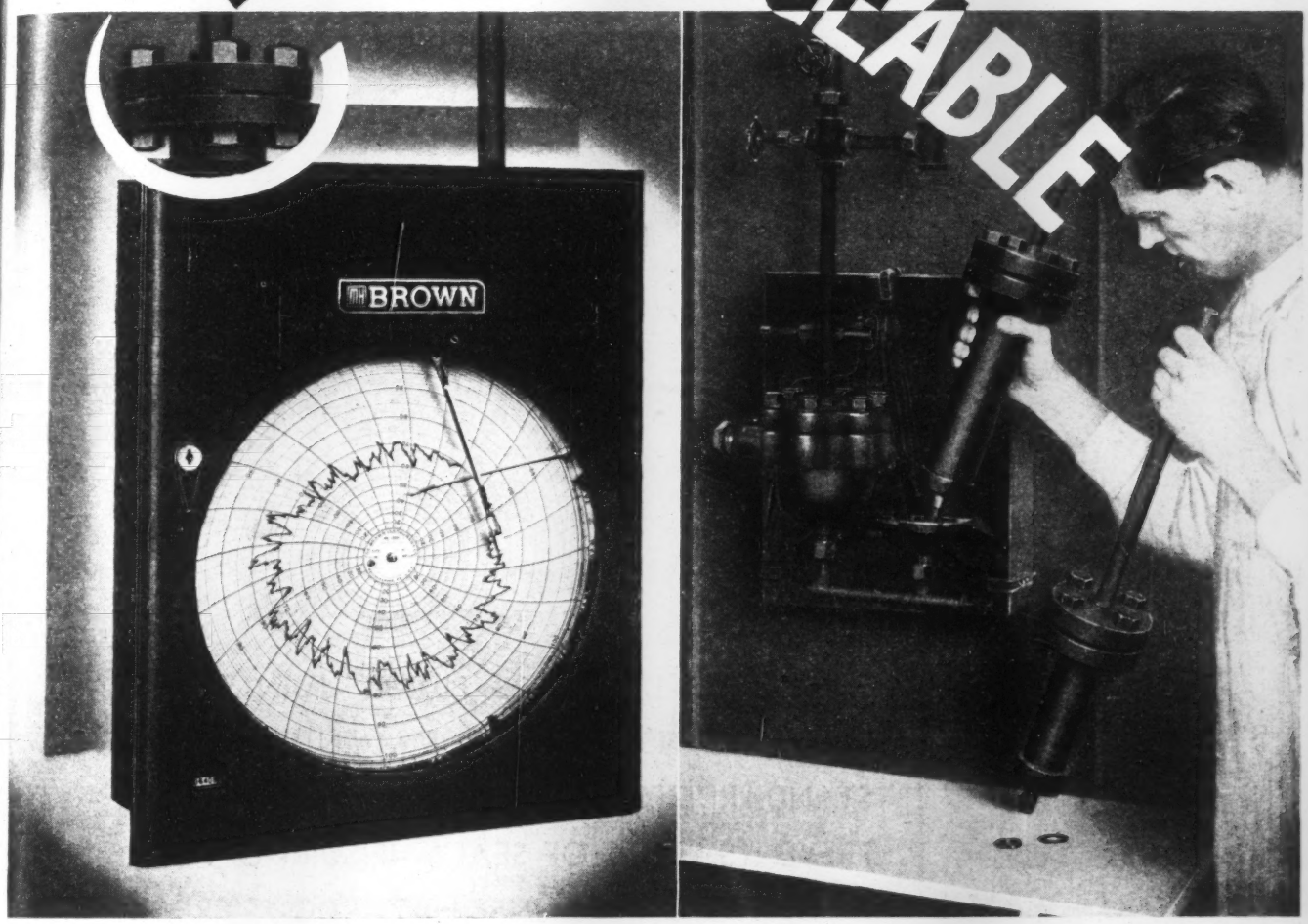
AEROVOX

INDIVIDUALLY TESTED

AEROVOX CORPORATION, NEW BEDFORD, MASS., U. S. A. • SALES OFFICES IN ALL PRINCIPAL CITIES

Export: 13 E. 40 St., New York 16, N. Y. • Cable: 'ARLAB' • In Canada: AEROVOX CANADA LTD., Hamilton, Ont.

INTERCHANGEABLE



INTERRELATED RANGE TUBES

THE easy range-changing feature of the Brown Mechanical Flow Meter has proved to be of great advantage to users.

If the original flow estimate is found in error (as it is in many cases) or if the average rate of flow changes (as it frequently does), the orifice need not be disturbed, nor another meter body installed to obtain the required range. With the Brown Mechanical Flow Meter all that is required is to install a *new range tube* of proper size in the meter body and use a chart of matched range in the recorder.

Range tubes make range changing easy—quick—inexpensive—no shutdowns or loss of records.

Seven interchangeable range tubes make it possible to get a four to one change in meter capacity in steps of roughly 25 per cent.

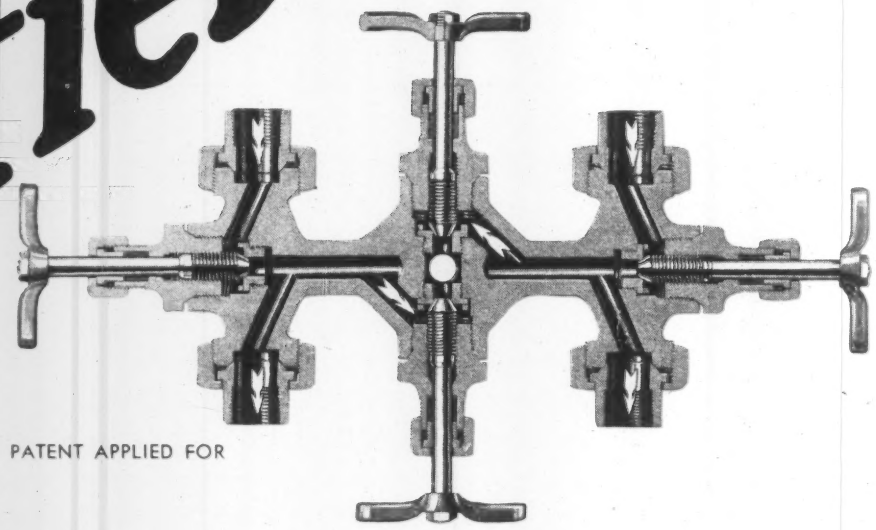
Other range tubes (25, 50, 100 and 200 inches of water differential capacity), and special range tubes for liquid level applications, are also available.

When ordered a valve manifold is supplied as an extra for all flow applications and for liquid level applications when required. Equipped with two shut-off valves and equalizing valve of forged steel with stainless steel trim.

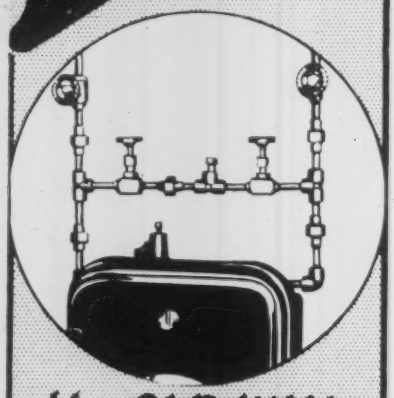
Write for Catalog 2204, THE BROWN INSTRUMENT COMPANY; a division of Minneapolis-Honeywell Regulator Company, 4482 Wayne Avenue, Philadelphia 44, Pa. Offices in all principal cities, 119 Peter Street, Toronto, Canada—Wadsworth Road, Perivale, Middlesex, England—Nybrokajen 7, Stockholm, Sweden.

BROWN FLOW METERS
. . . MINNEAPOLIS - HONEYWELL CONTROL SYSTEMS . . .

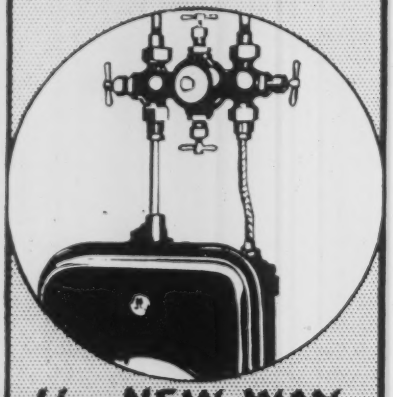
The New Belfield FLOW METER MANIFOLD VALVE



PATENT APPLIED FOR



the OLD WAY



the NEW WAY

ELIMINATES UP TO 22 PIPING JOINTS . . . . .

MINIMIZES INSTALLATION & MAINTENANCE COSTS .

STANDARDIZES METER PIPING . . . . . .

PREVENTS "LOSS OF SEAL"—INSURING YOUR INSTALLATION AGAINST HAZARDOUS BREAKDOWNS

THE FOLLOWING CONSTRUCTIONAL FEATURES ARE FURTHER EVIDENCE OF *"ENGINEERED DESIGN FOR FIELD RESULTS"*

1. DESIGNED TO FIT ALL METERS.
2. Seats, discs and stems of high grade stainless steel; give permanent life to the Manifold; seats are renewable.
3. Stem threads are of micrometer adjustment to prevent surge when valves are first opened.
4. With valve fully open, pressure on the stuffing box is shut off—this allows the valve to be packed with pressure on the system.
5. Suitable for working pressures up to 1500 p.s.i. in steel and 450 p.s.i. in bronze.

For full information regarding this and other Belfield Products, consult our Engineering Department.

NEW YORK OFFICE - 225 BROADWAY, N. Y. C.

REQUEST BULLETIN #644

Since 1836

H. BELFIELD COMPANY

BROAD and HAMILTON STS., PHILADELPHIA 23, PA.

DESIGNERS, ENGINEERS, MANUFACTURERS OF REGULATING VALVES, CONTROL VALVES & STEAM SPECIALTIES

write for new bulletin GCV-102

LABORATORY VOLTAGES accompany your equipment into the field with built-in CONSTANT VOLTAGE

On the drafting boards of hundreds of sales-minded design engineers, product insurance is being written into the specifications of new electronic and electrically operated equipment.

A critical analysis of sales department records of past performance usually discloses that the most frequent cause of equipment failure or sub-standard performance is the one most often overlooked — field voltages that do not correspond to the rated voltage at which the equipment is designed to operate.

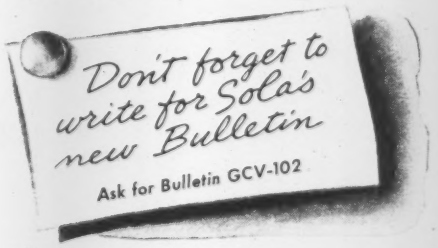
Today sales-minded design engineers make certain that carefully controlled laboratory voltages, on which the operation of their equipment is predicated, go with it into the field, by writing "SOLA Constant Voltage Transformers" into their design specifications. In many cases the inclusion of the "CV" transformer is accomplished at an actual saving in cost over standard equipment design.

Thus rated voltage is available at all times because SOLA Constant Voltage Transformers instantly correct fluctuations as great as 30% to less than ±1% of rated requirements. These sturdy, automatic transformers require no pampering or supervision. They protect both themselves and the equipment against line surges and short circuits.

Standard units are available in capacities from 10VA to 15 KVA or special units can be built to your specifications.

Constant Voltage Transformers

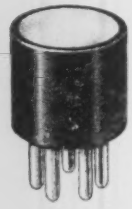
SOLA



Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • Door Bells and Chimes • etc. **SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago 14, Ill.**

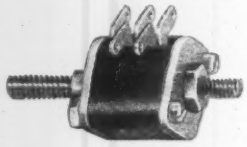
NEW RECTIFIERS FOR SIMPLIFICATION OF CIRCUIT DESIGN PROBLEMS

STANDARD MODELS OF COPROX RECTIFIERS



Coprox Model CX-2E4-A9, ring-connected and mounted in tube base, detects phase differentials in A.C. currents and small D.C. potentials applied to balanced A.C. circuits. Maximum 4.5 volts continuous. Shown here in actual size.

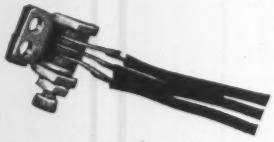
Coprox Model CX-1C2B1, a center tap, full wave rectifier. Completely enclosed in Bakelite. Low capacitance. Rectifies high frequency current. Conservatively rated up to 4.5 volts A.C., 3.0 volts D.C., 500 microamperes D.C. Other models and capacities to meet all needs.



Coprox Model CX-4D4F23, a full wave rectifier with high conversion efficiency, for electronic control work. Rated at 5 volts A.C., 40 milliamperes D.C. continuous. Fully enclosed. Mounts on a single screw.

Coprox CX-3E8C3 double bridge rectifier with current and temperature current characteristics balanced to better than 1% over a range of —40°C to +70°C. Rated up to 4.5 volts A.C., 3 volts D.C. 5 milliamperes D.C. Other models and capacities to meet all needs

Coprox CX-2E1H5 (Not illustrated) Single half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 2.5 milliamperes D.C.



Coprox CX-2E2D4 (Above) Double half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 2.5 milliamperes D.C.

Coprox CX-2E4F2 (Not illustrated) Full wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 5 milliamperes D.C.

Many variations are possible with the basic Coprox Rectifier models described at the left. Bradley's application experience can help you, not only in the use of these units but also in the development and production of special rectifiers for special jobs. Here are the special features of all Bradley Coprox Rectifiers:

- *Gold coating of "pellets" to combat aging.*
- *Pre-soldered lead wires, or special terminals, to prevent overheating during assembly.*
- *High leakage, low forward resistance, for efficient operation.*
- *Waterproof lacquering or wax potting, for perfect sealing.*
- *Highly adaptable mountings.*
- *Ratings are very conservative.*

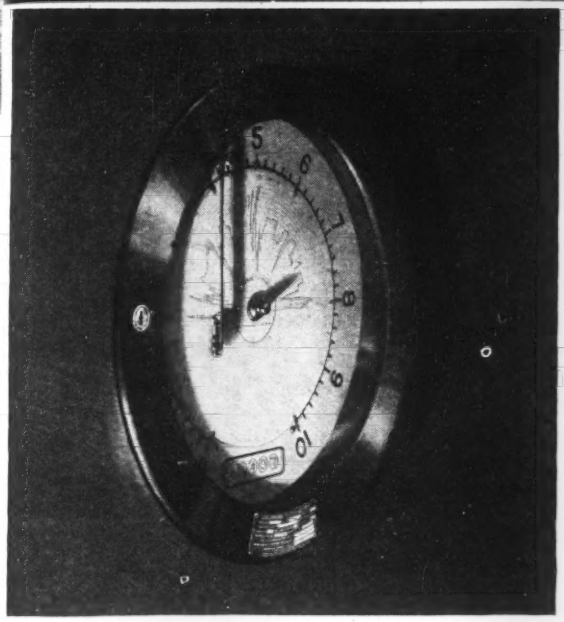
For samples and special data which will help you design more efficient circuits that will stand up longer than others, write Bradley. Ask any questions you have in mind.

LUXTRON PHOTOCELLS

A Bradley booklet is available, to suggest the many ways in which Luxtron* photocells can be used for control and testing purposes. These cells generate sufficient current to operate instruments and instrument relays without amplification. They, too, are built for long life and have varied mountings and a wide range of sizes. (*Trade Mark Reg. U. S. Pat. Off.)

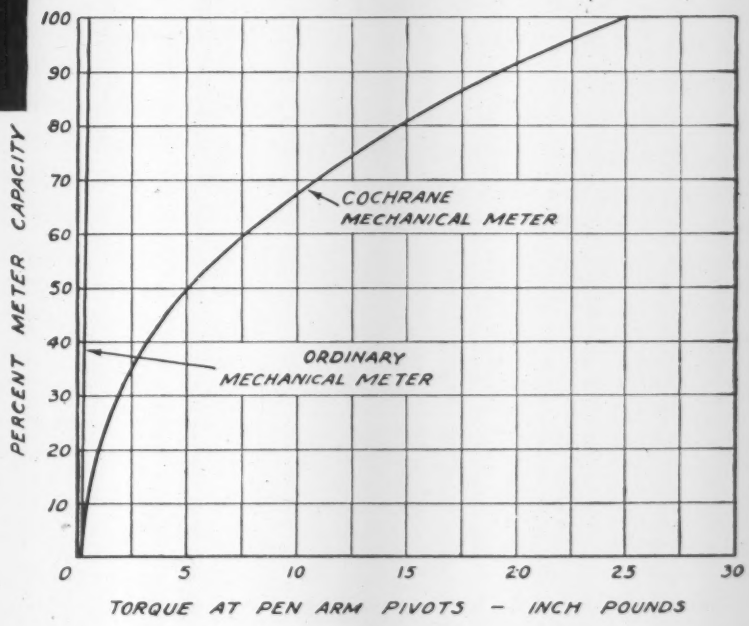
BRADLEY LABORATORIES, INC.
82 MEADOW ST., NEW HAVEN 10, CONN.

ACCURACY = POWER / friction *



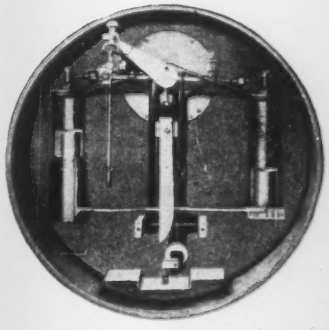
The Most Powerful Flow Meter Ever Made

That is an unusual statement to make about any commercial product, but the evidence, as shown by the test chart at the right, leaves no room for doubt. • At high scale, the Cochrane Tilting U-tube Meter develops a torque of 56 inch-pounds (8 lbs. of mercury operating on a 7-in. radius). Other mechanical type meters develop only a few ounces of torque.



THE SECRET OF COCHRANE POWER

The difference in rate of flow in the pipe line changes the level of the mercury in a sealed U-tube which is balanced on a knife-edge bearing. As the mercury shifts from one side to the other of the U-tube, the balance swings, moving indicator, pen arm and integrator to record the change in flow. Simple... powerful... never-failing. If you have a tough metering job, if your operators are unskilled in instrument care and maintenance, if you want the simplest and most powerful flow meter made, this Cochrane Tilting U-tube Meter was made for you. Write today to Cochrane Corporation, 3120 N. 17th St., Philadelphia 32, Pa.



**Power as expressed in the formula at the top of this page, in ratio to low friction, is the secret of flow meter ACCURACY*

CINAUDAGRAPH

.. it's also pronounced "PERMANENT MAGNETS"

Many have asked us, particularly in recent years, "Where's the connection between 'CINAUDAGRAPH' and 'PERMANENT MAGNETS'?" There's a clue . . . in fact, two clues . . . as to the connection. Analyze our company name carefully and you'll get it.

Yes, our interest in permanent magnets goes back many years . . . back to a period when we manufactured electronic equipment and designed and made our own magnets. Thus, our knowledge of permanent magnets encompasses not only their design and manufacture but their application.

Today, as for some years past, our business is exclusively "PERMANENT MAGNETS". And much of the knowledge stored up has been set down in writing in the pamphlet illustrated at the left. If you are working on the design of magnets or are using them, you should have this information in your files. Send for your copy.

Send for our pamphlet
PERMANENT MAGNET DESIGN

CINAUDAGRAPH CORPORATION

4 SELLECK ST. STAMFORD, CONNECTICUT

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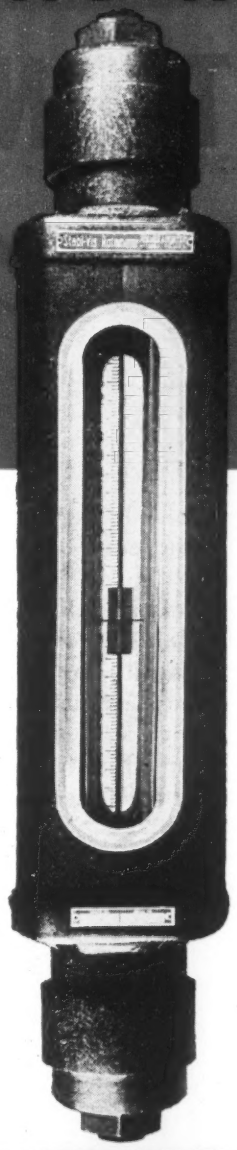
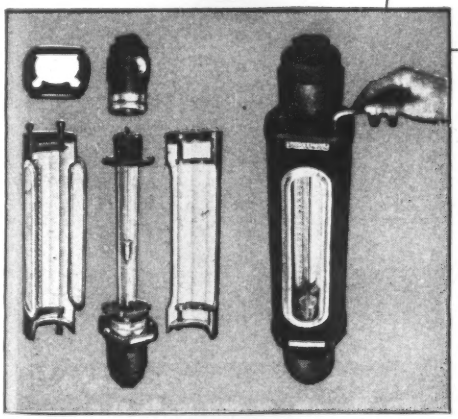
The new *Master-Enclosed* ROTAMETER

. . . . . the answer to an Instrument Engineer's PRAYER



Dear Fischer & Porter:

Please give me a rotameter for flow-rate measurement that is fully enclosed with safety glass windows so that my workmen are protected and so that no pipe fitting "butchers" can wreck the metering tube. Make it rigid so that it will take full pipe strain without "giving" but, if it isn't too much to ask at the same time, make it so that by removing a couple of little nuts or screws it will fall apart in my hands for easy repairs. And then, of course, it has got to be highly accurate so that it will really tell me what's going on.



This illustration shows how easily the meter comes apart, and how simply the flanged packing glands may be tightened without opening the meter.

Dear Mister Engineer:

We received your letter and did something about it. In fact, we obtained sketches and written ideas from 250 engineers, and then designed the new Master-Enclosed Rotameter.

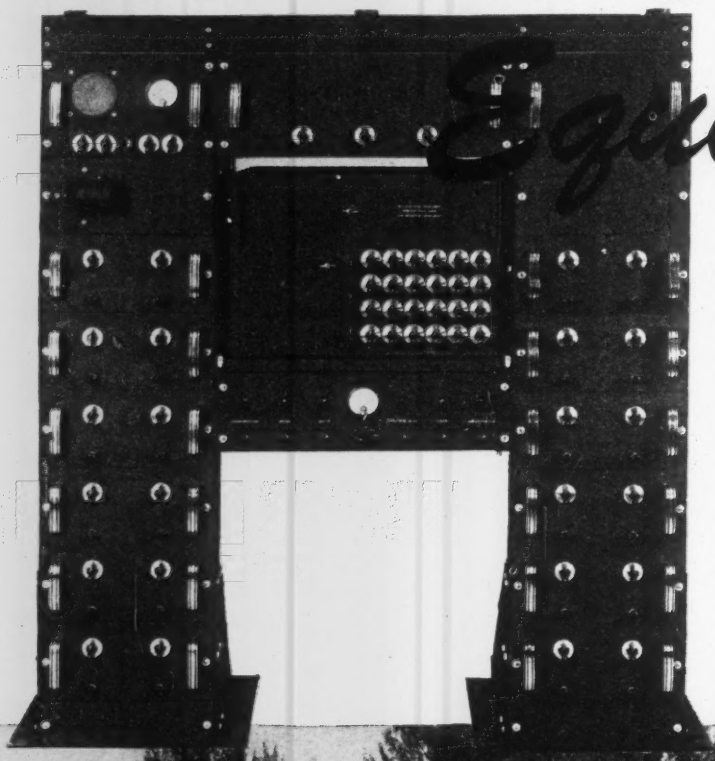
It *is* fully enclosed—it *is* rigid—it *will* come apart readily—it *is* highly accurate. Don't believe us—send for Bulletin 25-D, which gives the complete and instructive details.

FISCHER & PORTER COMPANY

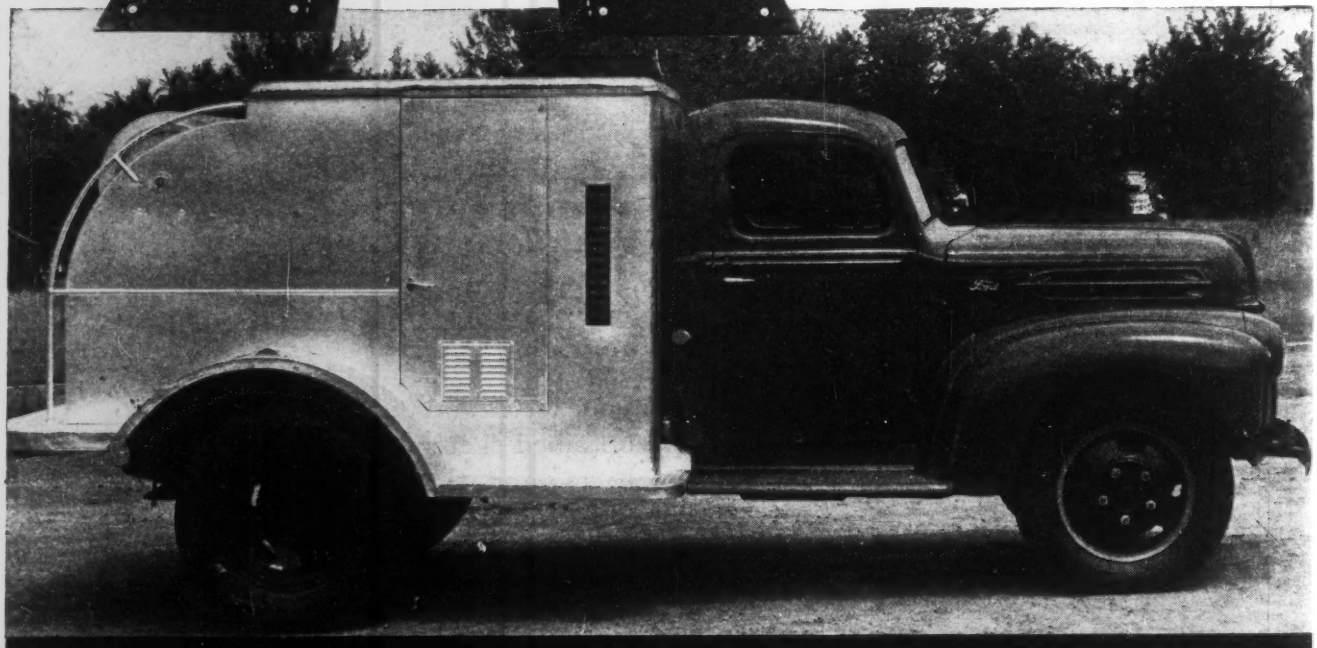
2302 COUNTY LINE ROAD • HATBORO • PENNA.

Fischer & Porter has pioneered EVERY basic rotameter improvement!

SEISMIC REFLECTION *Equipment*



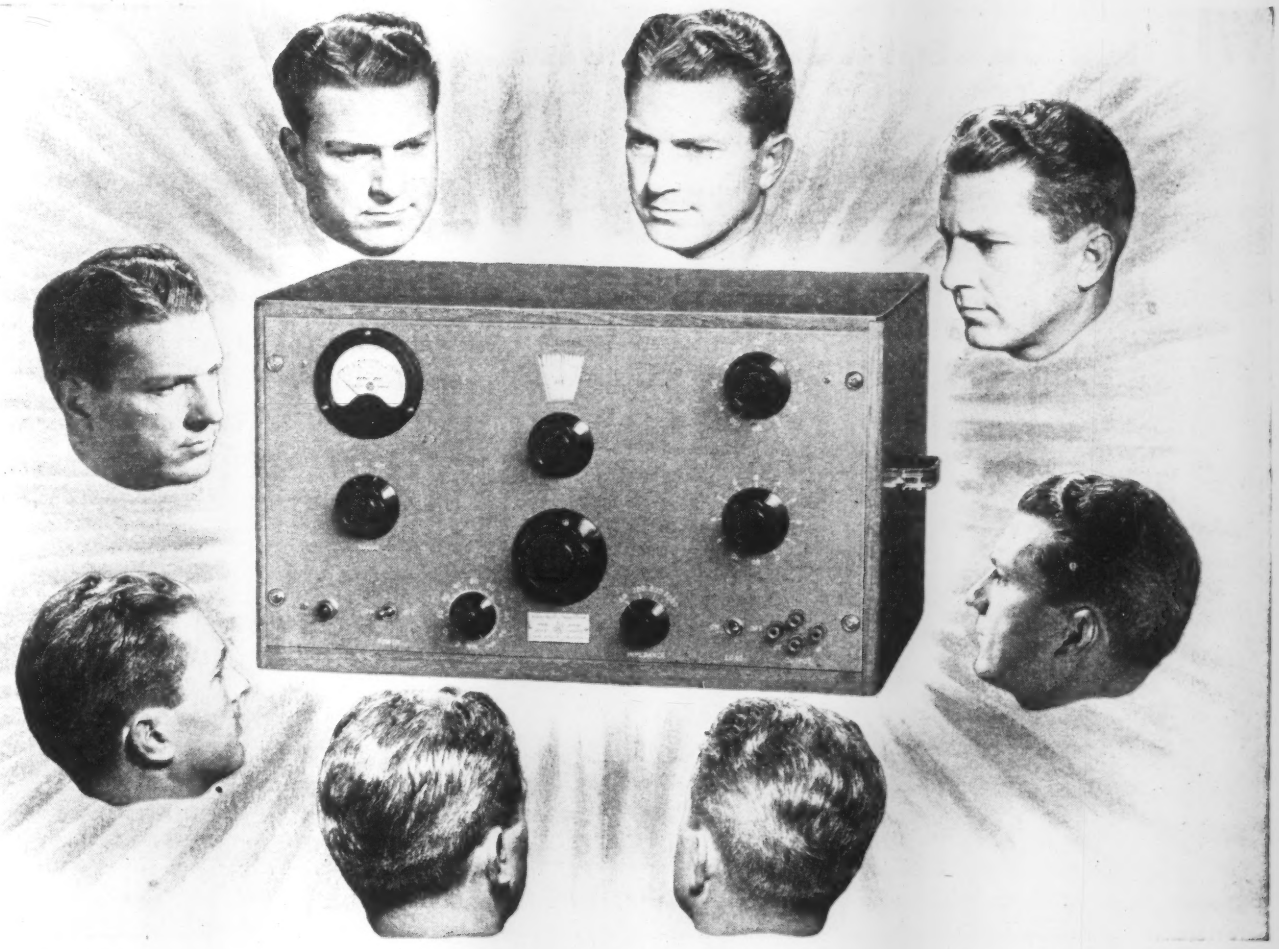
Equipment for seismic reflection shooting has to be ruggedly constructed to assure reliable and continuous operation in all types of terrain. Heiland Reflection Equipment is quantity produced to quality standards. Much of it has been in service so long that its year after year reliability has come to be universally accepted in the U.S. and abroad.



HEILAND RESEARCH CORPORATION
DENVER, COLORADO

YOU ARE LOOKING AT
ANOTHER NEW-*hp*-INSTRUMENT

...a signal generator for use below 100 kc



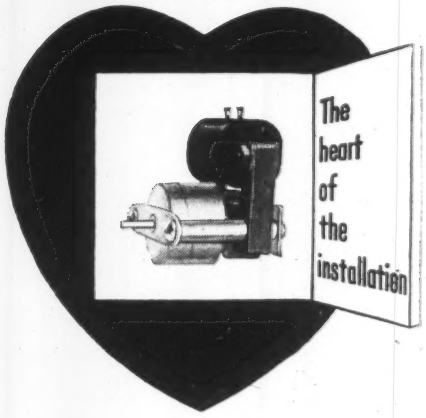
This new -*hp*- Audio Signal Generator embodies many new features which are very desirable. Outstanding among these is the new main frequency dial which enables the engineer to make extremely accurate settings. Parallax is completely void and the vernier adjustment is smooth and positive. A spring loaded gear drive, built on a heavy cast frame, maintains accuracy of settings. The Model 205-AH consists of an -*hp*- Resistance-Tuned Audio Oscillator, an output meter, an impedance matching system and an attenuator set. The frequency range is from 1 kc to 100 kc, maximum power output is 5 watts, the hum level is at least 65 db below output voltage and the frequency response is ±1 db from 10 kc reference. The output attenuator provides 0 to 110 db in 1 db steps, while the output meter is calibrated directly in volts at 500 ohms and in db above 1 milliwatt level.

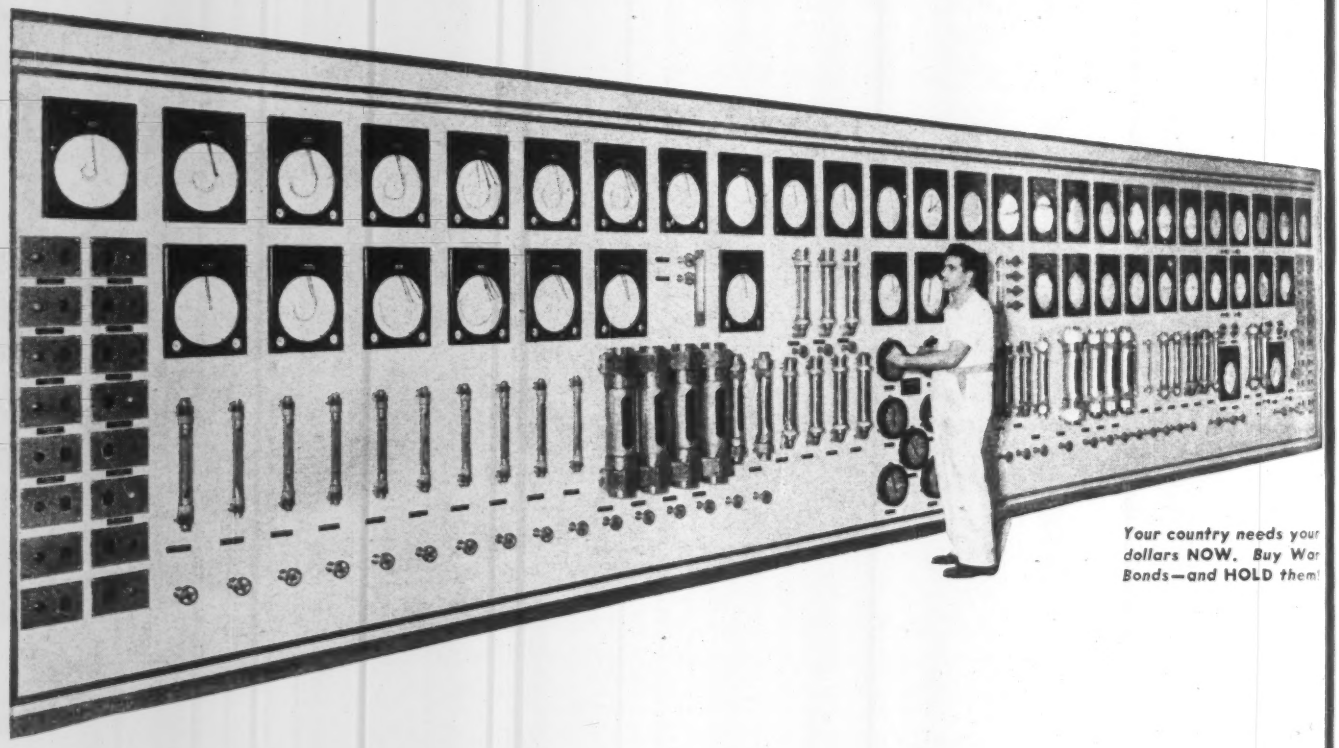
A limited number of preliminary specification sheets are ready for engineers who write immediately.

HEWLETT-PACKARD COMPANY

BOX 980C STATION A · PALO ALTO, CALIFORNIA

SPEEDING SPIRITS FOR WAR USE WITH TELECHRON MOTORS





Your country needs your dollars **NOW.** *Buy War Bonds—and* **HOLD** *them!*

WHEN war called for greatly increased supplies of industrial alcohol, installation of this control panel helped a midwestern distillery to step up its production of high-proof spirits. These control instruments made possible the quick conversion of a low-proof distillate tower to production of 190-proof alcohol.

Each of the recording and controlling instruments is driven by a *synchronous, self-starting Telechron motor.* They record and control the feed to the tower, the steam used in distillation, temperature of the cooling water, and the vacuum in the tower. Their smooth, constant speed keeps the distillation process at peak efficiency—around the clock.

Telechron motors are available in sizes from 12 to 250 volts for all commercial frequencies—and from 1 to 1800 rpm. Accurate, dependable and flexible, they are used in all kinds of industrial operations. Their applications include:

TIMING	*CYCLING OPERATIONS*	*MEASURING*
CONTROLLING	*SIGNALING*	*GAGING*
METERING	*FIXED PROCESS CONTROLLING*	*REGULATION*
RECORDING		*COMMUNICATIONS*
SWITCHING		

Our more than 25 years' experience in making synchronous, self-starting motors for instrumentation is available to you for the asking. Just write Motor Advisory Service, Dept. A.

Telechron

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WARREN TELECHRON COMPANY • ASHLAND, MASSACHUSETTS

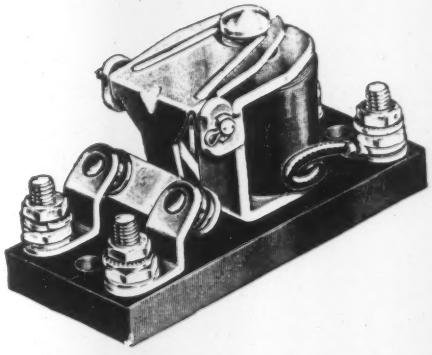
MAKERS OF TELECHRON ELECTRIC CLOCKS AND SYNCHRONOUS ELECTRIC MOTORS

STRUTHERS-DUNN

INC.

~~5,288~~ 5,312

TYPES OF



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Each available in countless coil combinations

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Reflection of Superior

NOT only does the image in the mirror show a view of these 1 KVA POWERSTATS but it reflects the years of experience gleaned by SECO engineers in designing variable voltage transformers. All the "know-how" gained through laboratory research, technical achievement, and customer demand is incorporated into these new 116 and 216 models . . . assuring a POWERSTAT with features offered by no other unit of comparable size.

	TYPE 116	TYPE 216
Input	115 volts, 50/60 cycles	230 volts, 50/60 cycles
Output voltage	0-115 and 0-135 volts	0-230 and 0-270 volts
Output current	7.5 amperes available over entire output voltage range.	3.0 amperes available over entire output voltage range.
Output watts	1000 va	810 va
No-load power loss	3.5 watts	3.5 watts
Dimensions	Over-all —— 5 1/16 x 6 7/8 x 6 3/8 inches high 3 mounting holes — 120 degrees apart on 2½ inch radius.	

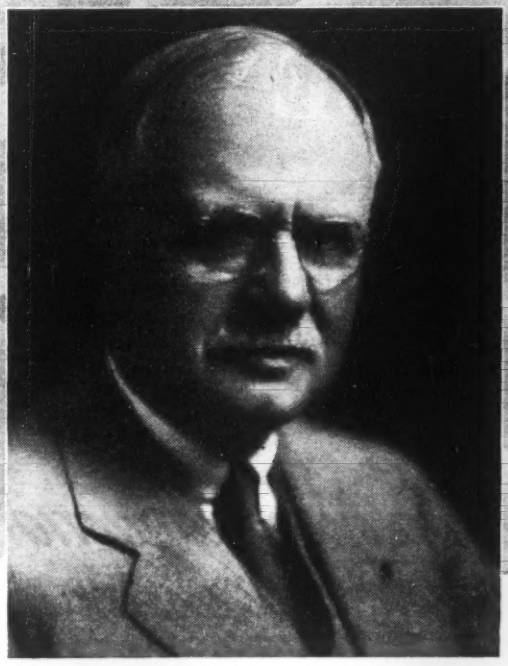
As illustrated, this type of POWERSTAT is available either cased or uncased . . . the uncased model designated by the letter "U" following the type number.

For further information, write for your copy of bulletin 116 SI.

SUPERIOR ELECTRIC COMPANY

421 LAUREL STREET • BRISTOL, CONNECTICUT

"Our Business, Like Yours, ...is *Different!*"



A few comments based on the first 50 years of the JAMES G. BIDDLE COMPANY

BUSINESSES, like people, usually have distinct, individual personalities. The smaller the business, the more clearly it will reflect the character of the man who built it.

In 1895, when the electrical industry was in its infancy, James G. Biddle went into business as a manufacturer's agent, selling electrical measuring instruments and scientific apparatus. One of his basic aims in the conduct of the business was to be more than a mere source of supply. He decided to provide a service that was outstanding by reason of its alert, interested, personal character. This aim has never been changed by Mr. Biddle or his associates during the last half century. It will continue to be an important factor in the policies of the James G. Biddle Company in the years to come. We are committed to this.

•

In celebration of our 50th anniversary, we have prepared a brief booklet entitled "Report at Mid-Century." It touches upon interesting points regarding the growth and advancements of the electrical field in general and our business in particular. We would be pleased to send you a copy upon request.

JAMES G. BIDDLE CO. • 1211-13 ARCH STREET • PHILADELPHIA 7, PENNA.

"MEGGER"* INSULATION TESTERS, GROUND TESTERS AND OHMMETERS • "FRAHM" TACHOMETERS AND FREQUENCY METERS • "JAGABI" RHEOSTATS • INDICATING HAND TACHOMETERS • SCIENTIFIC APPARATUS

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SPERRY GYROSCOPE COMPANY, INC.
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WILCOX ELECTRIC COMPANY
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RAYTHEON MANUFACTURING COMPANY
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THE BEST KNOWN NAMES ON THE WAR PRODUCTION FRONT DEPEND ON THORDARSON QUALITY

Throughout the trying periods encompassed by 3 wars . . . and in all the intervening years of peace since 1895 . . . Thordarson leadership has been accentuated by its association with the most outstanding concerns in America.

Especially on the present world-wide war fronts...where the marvels of research laboratories and the handiwork of production geniuses may be seen in action...there also will be found the results of Thordarson experience and Thordarson engineering ability.

Thordarson Transformers and Amplifiers are "good right hands" to a host of America's leading organizations who are concentrating on winning the war as quickly as possible. Thordarson products are helping to do everything from making communications easier and more accurate to conducting fatigue tests which insure more dependable airplane propellors. All of these services and experiences, now devoted to war, will enable us to serve you better when peacetime needs are again paramount.

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TRANSFORMER DIVISION
THORDARSON ELECTRIC MFG. CO.
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Transformer Specialists Since 1895
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VISUAL INSPECTION of INTERNAL SURFACES *with* POLAN BORESCOPES

For work in which the inspection of internal surfaces is a factor, Polan Borescopes give detailed, minute inspection.

Requiring no special operator training, Polan Borescopes are practical in usage. Designed for inspection of gun bores, bored engine shafts, cylinders, etc., with absence of eye fatigue. Efficient inspection of bore diameters ranging from 20mm to 9 inches; lengths up to 30 feet.

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Polan *Industries*

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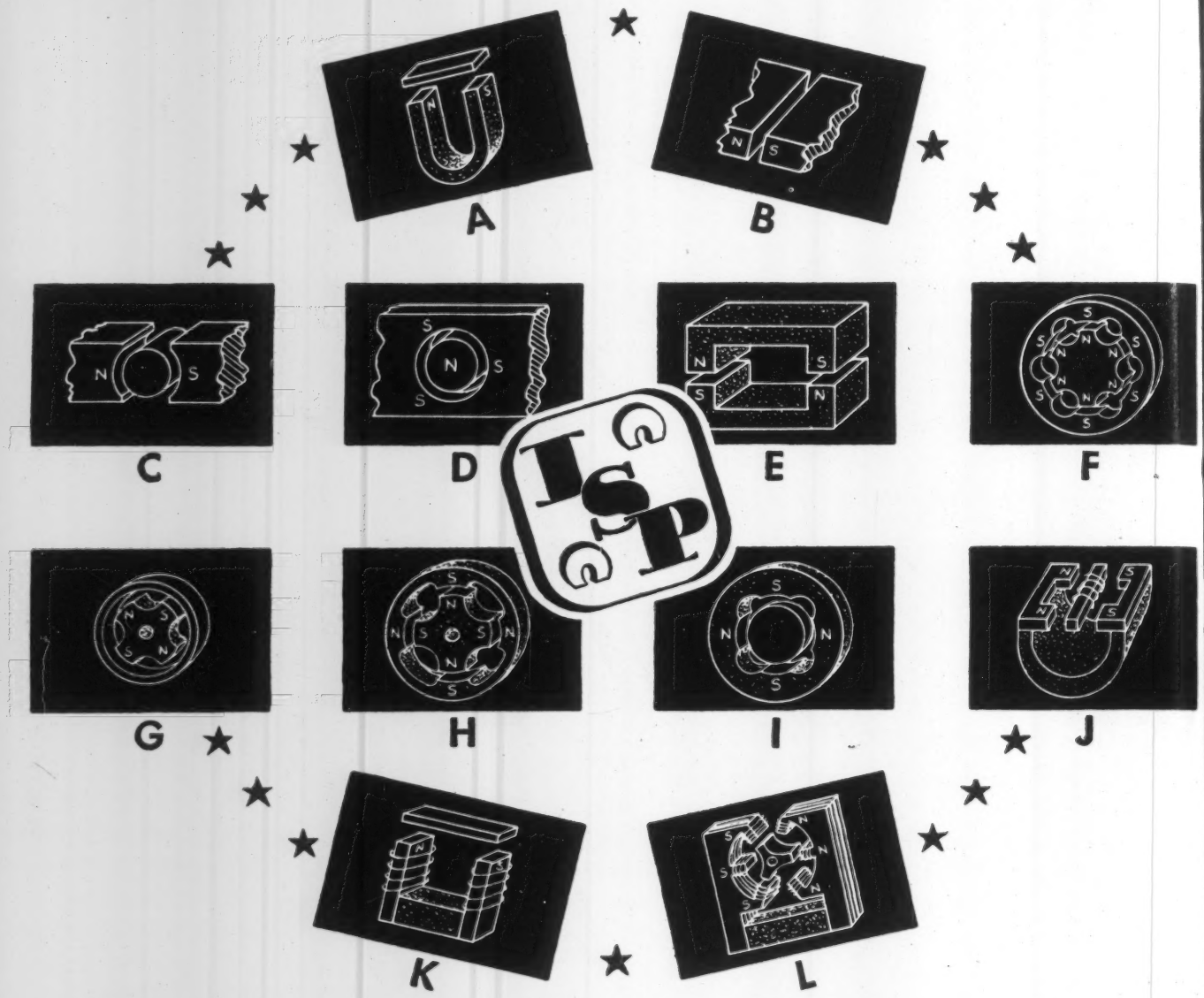
PERMANENT MAGNETS MAY DO IT BETTER



Basic Types of Air Gaps

The space required for a magnetic field is known as an "air gap." Most of the fundamental types of air gaps are illustrated above—from the familiar form shown in "A," which is simply a permanent magnet with an armature adjacent to the poles of the magnet, to the inductor type alternator such as type "L."

The basic forms of permanent magnets and their associated air gaps are subject to infinite variations. They are used in a rapidly growing number of applications . . . potentially, there are unlimited uses for permanent magnets as yet undiscovered.

In specializing in permanent magnets since 1910, we have discovered and engineered many advances in magnetic technology with the result that this company is now the largest in the country manufacturing permanent magnets exclusively.

If you are making products which might function better through the employment of magnetic energy, our engineers will be pleased to consult with you. Write for complete information. Ask for a copy of "*Permanent Magnets Have Four Major Jobs.*"

THE INDIANA STEEL PRODUCTS COMPANY

6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILLINOIS

ARMY E NAVY

Specialists in Permanent Magnets Since 1910

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PERFECT EXPOSURE BECAUSE OF SHUTTERS AND FLASH-BULBS CHECKED BY DuMONT *Oscillography*

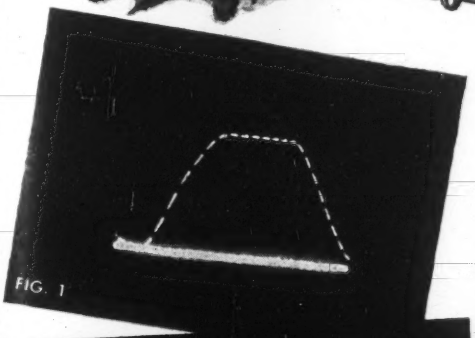
FIG. 1

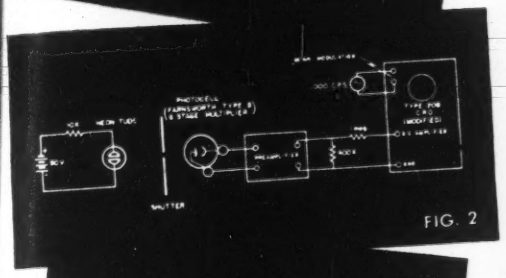
FIG. 2

FIG. 3

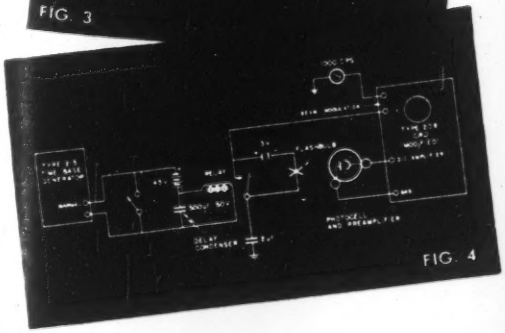
FIG. 4

Testing of photographic shutters; measurements of flash-bulb characteristics; calibration of lens diaphragm openings; comparison of transmission factor of lenses; opacity and density measurements—such are typical applications of versatile *DuMont Oscillography* to still better photography.

Typical of this technique is the precise checking of shutter speeds. Fig. 1 shows an oscillogram obtained with arrangement in Fig. 2. Light intensity passing through shutter is directly plotted as a function of time.

When shutter opens, light from neon lamp falls on photo-cell. Both cell and neon lamp operate on D.C. Output from photo-cell directly, or D.C. amplified if necessary, is applied to vertical deflection plates of cathode-ray tube. A timing wave modulates the cathode-ray beam, so that plot appears as dotted line. the distance between two adjacent dots being determined by the period of the timing wave.

This oscillogram discloses the elapsed time for the opening shutter, the full opening, and the closing shutter, calibrated in time elements of 1/1000ths of a second.

Fig. 3 discloses the characteristics of a flash-bulb again in terms of 1/1000ths of a second. Equipment used is shown in Fig. 4. A relay, delayed for about 1/30th second, starts the flash after the start of the single sweep.

This flash-bulb checkup determines: (1) Time elapsing between closing of battery contact and start of flash; (2) Duration of flash itself; (3) Measurement of peak luminous output; and (4) Determination of total light output (by integration).

Typically *DuMont Oscillography*. No doubt there is an equally important application in your laboratory, on your production line, or out in the field. Submit your problem for our suggestions and engineering help.

Write for Literature

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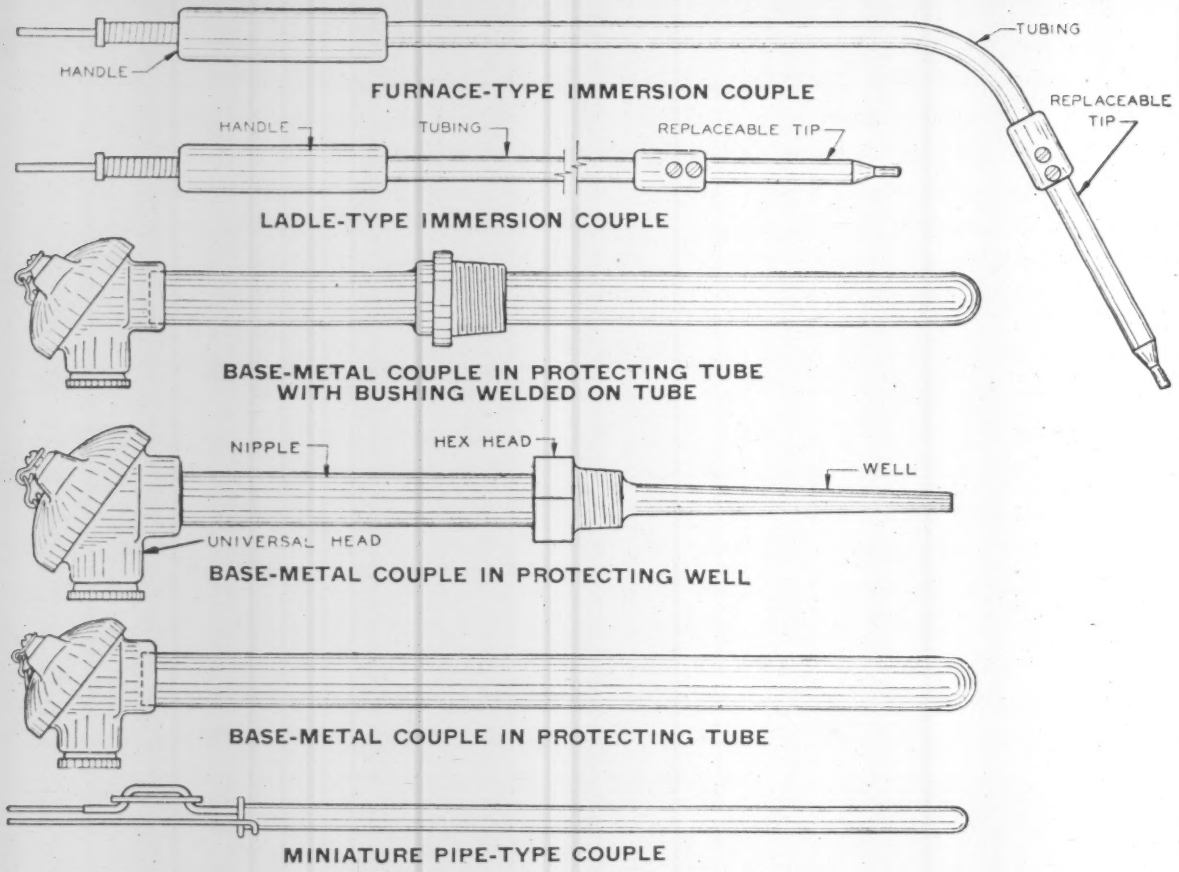
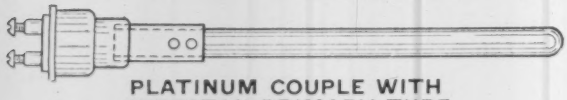
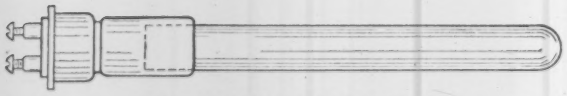
DUMONT *Precision Electronics & Television*

ALLEN B. DuMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: WESPEXLIN, NEW YORK

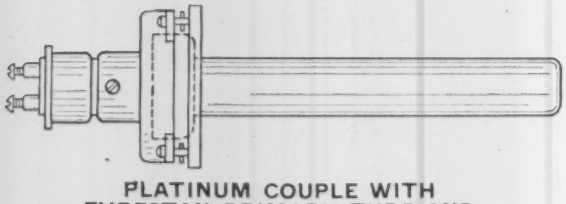




PLATINUM COUPLE WITH
FYRESTAN PRIMARY TUBE



PLATINUM COUPLE WITH
FYRESTAN PRIMARY AND SECONDARY TUBES



PLATINUM COUPLE WITH
FYRESTAN PRIMARY TUBE AND
SILICON CARBIDE SECONDARY TUBE

THERMOCOUPLES

Because the reliability of a thermocouple pyrometer depends to a great extent on its temperature detector, thermocouples and couple parts are a specialty with us—one to which much research and engineering, and many manufacturing and testing skills are devoted. Some of our widely-used designs are shown above, assembled in the shorter lengths for convenient illustration; we either assemble couples for your needs, or supply parts.

All wire for couples and extension leads is thoroughly checked for thermal electromotive force in our thermocouple laboratory. Instruments of our own make—special thermal-free low range potentiometers, our famed Wenner potentiometer which will reach down to one microvolt, and checking furnaces specially designed for this job—are used to check these wires with the same thoroughness devoted to checking our laboratory and industrial instruments.

L&N "all-weather" heads are an outstanding feature of our base-metal industrial couples. These heads give weatherproof protection to the asbestos-compound terminal block, and position the block by a single screw—inserting or removing the wires is a simple matter. Tubes of iron, steel, ceramic ware, and special alloys insure sensitive, durable protection for couples.

For complete listing of parts and assembled couples, send for Catalog N-33A(6).

Jrl Ad NS2(1)

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depends on me!
A Slogan For Every American

LEEDS & NORTHRUP COMPANY, 4955 STENTON AVE., PHILA., PA.

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MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

EDITORIAL COMMENT

What's Cooking?

PLENTY, brother, plenty in the sense of thousands upon thousands of new things for your postwar plant, laboratory, aircraft, vehicles, or other instrument application.

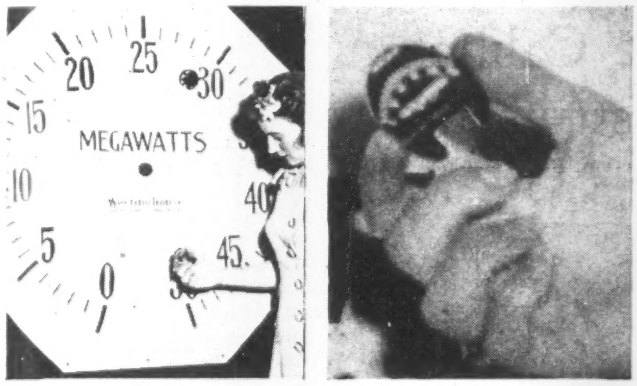
This is the thought that came to my mind when I read the first two lines on page 46 of the January *General Electric Review* which is entirely devoted to "Electrical Developments of 1944"—the annual review of G-E achievements which Guy Bartlett has been ably preparing for about ten years. These first two lines read as follows:

"More than 2000 new and variations of existing models of electric instruments were developed during the year."

The same mail brought a photograph and mimeographed news release from another giant corporation which makes electrical instruments among thousands of other electrical products, namely, the Westinghouse Electric & Mfg. Co. From the mimeographed story the following is quoted:

". . . These dials, largest and smallest made by Westinghouse, signify the tremendous range of sizes and types of electrical instruments . . . The huge dial is used in large generating plants. . . . On aircraft where space and weight are at a premium miniature instruments like that shown are installed . . ."

Owing to paper shortage I resisted the temptation of reproducing the 8 × 10 photo almost full-size to convey to you the effect it produces. I hope this will do it:—



From now on, no mere words of mine could do justice to such a big story! Every reader can write his own editorial in his own mind. Furthermore, many of you are engaged in activities—both military and civilian—where you use instruments, meters, testing machines, automatic-control systems, remote-control systems, automatic-inspecting machines, etc., etc., of new types, or of marvelously refined designs, which the censors have not yet released.

Yes, brother, plenty's cooking in the field of instrumentation! If America were to achieve a sudden victory over both the Nazis and Japs, and if the censorship were to be lifted suddenly over every scientific and engineering development now kept secret . . . AND if all of the thousand-odd instrument manufacturers were to release descriptions and photographs on the same day, we probably would have to wire the WPB Paper Conservation people, begging them to give us enough tonnage to bring out an issue in which "The Month's New Instruments" Department could print thousands of descriptions and pictures.

This is a big IF and the chances are that it will not happen this way. As a matter of fact, I'm happy to testify that the censorship has not been blindly rigid: on the contrary, both the Army and Navy censors have been permitting the disclosures of many new developments in the field of instrumentation. Thanks to their vision and understanding, numerous radically new developments HAVE BEEN REPORTED in this magazine—in feature articles as well as in the "New Instruments" Department.

Although I am not acquainted with more than a tiny fraction of what is going on in the research and development departments of instrument companies, I feel safe in asserting, furthermore, that a report such as that of G-E does not necessarily mean that every item included in the grand total is completely "new." Mr. Bartlett's words are "More than 2000 new and variations of existing models . . ." from which I assume that the great majority are "variations of existing models" such as tropicalized constructions for service in the Pacific. And even the "new models" are mostly, I assume, just what these words mean, rather than instruments and meters employing new principles, new circuits, etc.

On the whole, therefore, you need not look forward to a 400-page issue of *Instruments* a month or two following the day when our boys shall have achieved final victory. I don't know just how quickly the censors will lift restrictions and how quickly the thousand-odd instrument companies will prepare their descriptions. Nobody knows how this will be worked out. Of course, I am making plans to give you a first-rate reportorial job in this coming period of disclosures, but personally I believe that this period will last SIX MONTHS OR MORE, owing to the numerous problems involved in converting special war instruments to the needs of America's postwar civilian industrial structure. At any rate, brother, plenty's cooking!

—M. F. BEHAR

FRONT-COVER PICTURE STORY

Curtiss-Wright Propeller Test Cells

By CAMILLA McCOMBER

The new $500,000 Twin Test Cells recently constructed at Caldwell, N. J., by the Propeller Division of Curtiss-Wright Corp. are part of the largest privately owned laboratory of its type in the world, with many "firsts" to its credit.

For the first time two Venturi-type or "straight-through" chambers are provided for testing propellers up to 30 ft. in diameter driven by in-line or air-cooled engines of 5,000 hp. or more. (Largest props so far designed are 18½ ft., driven by 2200-hp. engines.) Whereas old propeller cells were L-type or U-type, originally built for engine or plane model tests, the new outsized twin chambers furnish airflow that simulates the straight airstream to which propellers are subjected in actual flight. Each of the twin cells is 38 ft. wide at the front and rear, constricting to a 31-ft. throat Venturi in the center.

Another unique feature is that engines and propellers of a wide variety of sizes can be mounted in the cells. Precise control of engine operation is afforded for the first time by a combination of cooling systems, with uniform uninterrupted airflow projected by blowers through the propeller disk on which engines are mounted.

An important feature is the soundproof control room located centrally between the twin cells, providing remote control for all equipment in both cells. For the convenience of operators, all essential controls for the stress-testing of engine-propeller units are grouped together around the observation windows, one of which faces each cell.

Another "first" is the Walter Kidde & Co. high-pressure "three-way" carbon-dioxide fire-extinguishment system.

Tuition-free War Training Courses at University of Pittsburgh

Classes begin Week of Feb. 19 and end in latter part of May.

[Announcement received too late for January issue. Readers receiving this issue at last moment might try 'phoning the ESMWT Office at the University, SChenley 8715. The following is an *incomplete* list, reporting only the courses of greatest interest to our readers in Western Pennsylvania.—Editor]

Department of Electrical Engineering
Electrical Equipment, Maintenance and Test—Course I
Industrial Electronics

Department of Industrial Engineering
Time Study
Advanced Time Study

Department of Metallurgical Engineering
Inspection and Heat-Treatment of Tool Steels

Department of Chemistry
Laboratory Techniques
Metallurgical Analysis II
Glass Blowing for the Laboratory
Food Testing and Control in Industry
Electrical and Optical Instrumentation

Department of Physics
Special Problems in Applied Spectroscopy
Special Problems in X-ray Diffraction

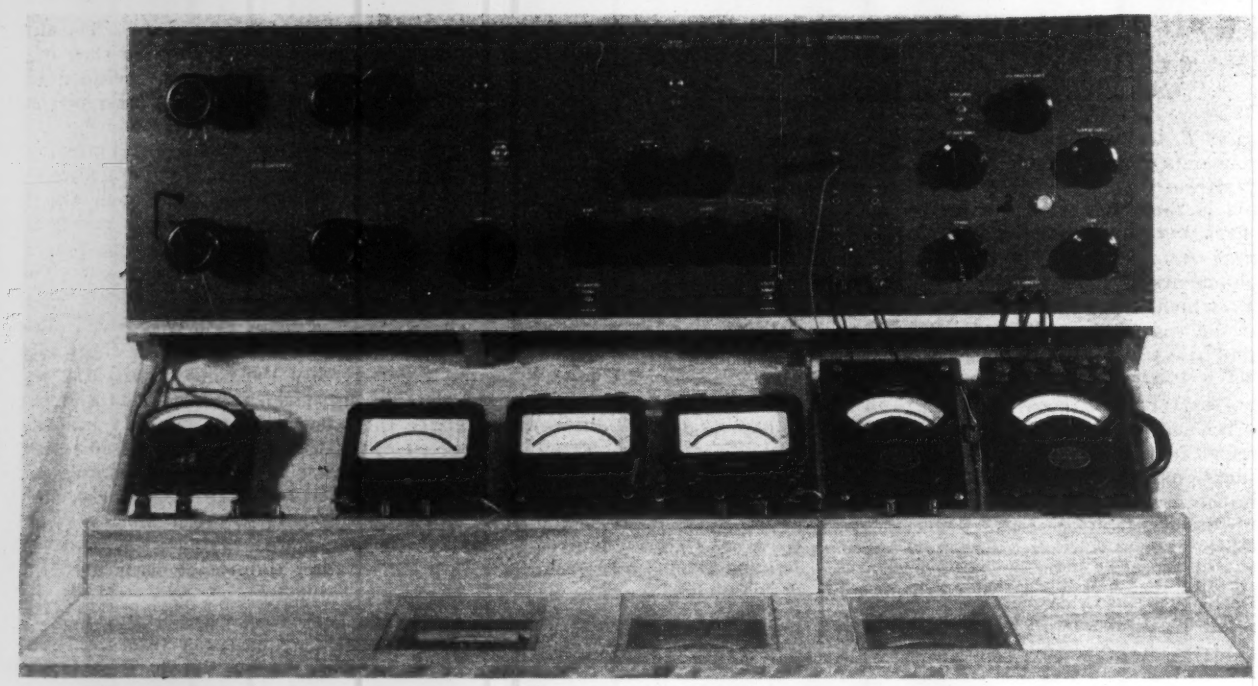


Fig. 1. Front view of upper part of test set, showing control panels and standard instruments.

A Versatile Semi-portable Calibrating Bench for Electrical Instruments

By MRS. N. M. GILBERT, Electrical Measurements Section, Bell Telephone Laboratories, New York City

WAR ACTIVITIES have greatly augmented the work carried on in our outlying laboratories, with a correspondingly large increase in the number of electrical instruments. To avoid the delay and inconvenience of returning the instruments periodically to West Street* for calibration, a test set has been designed that permits all ordinary voltmeters and ammeters to be quickly calibrated with engineering accuracy. For either a-c. or d-c. voltmeters, the range extends to 750 volts; for a-c. ammeters it extends to 100 amperes; and for d-c. ammeters, to 50 amperes. The first of these units is already in use at the Whippany (N.J.) laboratory.

As shown in Figs. 1 and 1A, the test set consists of a laboratory type table with control panels mounted above the rear edge, with standard instruments arranged along an inclined shelf beneath the control panels, and with horizontal space for placing the instruments under test. Beneath the top, and visible through plate glass windows, is a high-voltage compartment used for voltages greater than 150. It is equipped with an a-c. and a d-c. standard voltmeter with space between them for the instrument under test. Beneath this compartment are batteries for the d-c. voltage and milliampere tests, and on the shelf to the left is a 6-volt storage battery for d-c. ammeter calibration. Power for all a-c. calibration is taken from the 115-volt 60-cycle commercial supply.

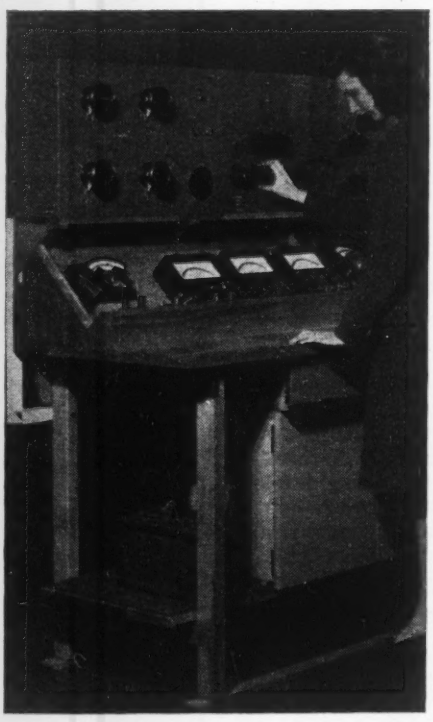


Fig. 1A. General view of test set.

A-c. calibrations are controlled from the panel at the extreme right and the narrow jack panel immediately to the left of it, which may be seen in Fig. 1. Associated with these panels are three standards: a two-range voltmeter (0-1.5 and 0-3 volts) and a two-range ammeter (0-2.5 and 0-5 amperes) on the inclined shelf directly beneath the control panel, and a two-range voltmeter (300 and 750 volts) in the high-voltage compartment. All are Weston instruments, the voltmeters being Model 341, and the ammeter, Model 370.

Control for all a-c. measurements is through two Variacs in the primary circuit of a power transformer that supplies seven testing voltages from its tapped secondary. The arrangement is shown in Fig. 2. A voltage regulator, arranged to be cut into or out of the circuit, is normally used for all voltage calibrations and for current calibrations up to 30 amperes. Because of its limited capacity, it must be cut out of the circuit for larger currents. One Variac gives coarse control of voltage, the other, fine. Connections are taken from the tapped secondary for both voltage and current calibrations through selector switches. After a range selection has been made, control is determined by adjusting the Variacs.

For a-c. voltage calibrations the circuit is as shown in Fig. 3. The upper left dial on the a-c. panel controls the two brushes marked *A* and *B* at the left to select the desired range. The brushes move together, with *B* selecting either

*Mrs. Gilbert's department is in the building at 463 West St. in the lower Manhattan district of New York City—where most of Bell Labs' standardization and calibration work is done.—EDITOR.

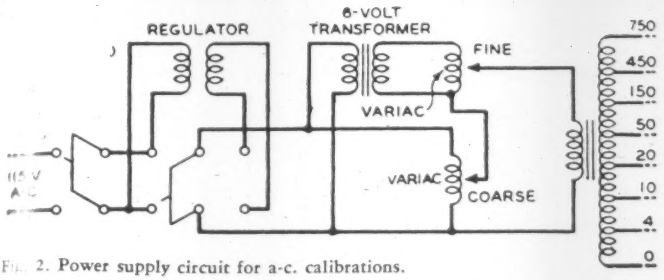


Fig. 2. Power supply circuit for a-c. calibrations.

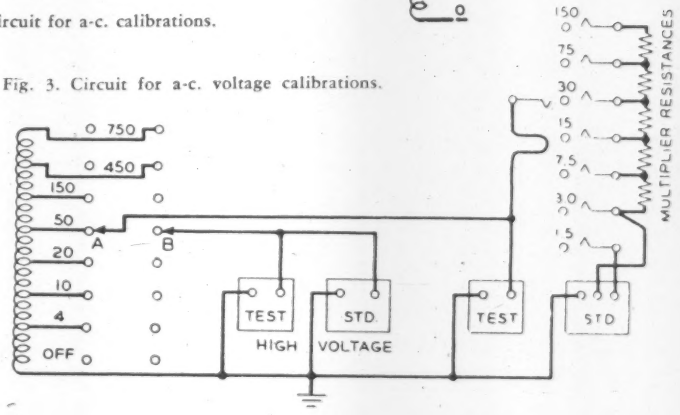


Fig. 3. Circuit for a-c. voltage calibrations.

the 450- or 750-volt transformer tap, for a high-voltage calibration, and *A* selecting for all other voltages. Above 1.5 volts, the 3-volt winding of the standard is used, but a chain of accurately-calibrated multiplier resistors connected in series with it permits the proper range to be selected by the plug and jacks on the narrow panel at the left of the control panel. After the proper voltage tap and the range of the standard have been selected, the voltage is adjusted to the proper value by the Variacs, controlled by the two dials at the bottom of the panel.

For a-c. current measurements, the circuit is as shown in Fig. 4. The upper central and upper right dials on the control panel are used. The upper right dial selects a transformer tap that will provide the desired amount of current, while the upper central dial, controlling the two brushes *C* and *D*, selects the proper range on the standard ammeter. For either 2.5 or 5 amperes the *C* brush makes contact directly to one of the two instrument windings, but for all higher currents, it makes connection to a tapped current transformer with a 5-ampere secondary.

For calibrating d-c. voltmeters, and d-c. ammeters up to 200 milliamperes, a range switch and two voltage-dividing resistors are employed in conjunction with four batteries: a 3-volt battery with a tap at 1.5 volts; a 45-volt battery not tapped; a 180-volt battery with taps at each 22.5 volts; and a 540-volt battery with taps at every 135 volts. The range switch is controlled by the upper left dial of the third panel from the right of Fig. 1, and the resistors are controlled by the two right-hand dials at the bottom of the panel. The standard instruments employed (all Weston Model 622) are: a voltmeter in the high-voltage compartment for measuring voltages above 150; a similar voltmeter, but with seven ranges extending from 1.5 to 150; a millivoltmeter with four ranges from 2 to 2,000 millivolts; and a milliammeter with four ranges from 0.2 to 200 milliamperes.

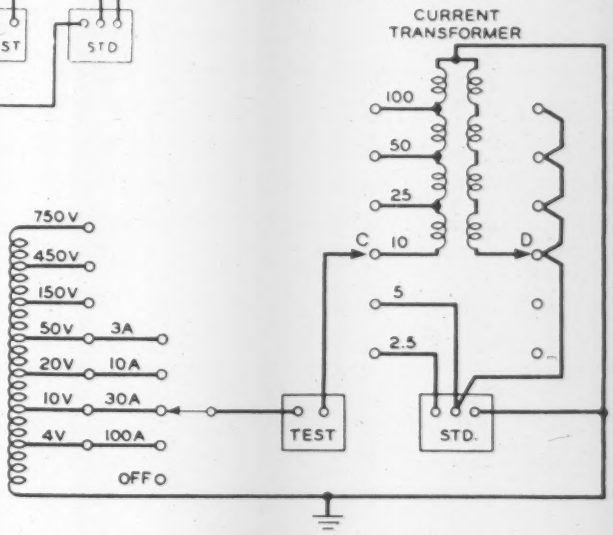


Fig. 4. Circuit for a-c. current calibrations.

In making a test, the range switch is turned to the proper position for the instrument to be calibrated, thus making a connection to the proper standard and also to the proper battery combination. The range switch on the standard instrument is also turned to the proper position. The voltage applied to the instrument is then controlled by two voltage-dividing resistors. These resistors, connected in series to give coarse and fine adjustment, will have been connected across either the 3- or 45-volt battery by the range switch. For voltages above 40, other batteries are connected in series with the voltage-dividing resistor.

For calibrations in the high-voltage compartment, the circuit is as shown in Fig. 5. Voltage adjustment is secured for the most part by the two dials at the lower left. One, marked "×135" and connected to the 540-volt battery, gives 135 volts per step, while the other, marked "×22" and connected to the 180-volt battery, gives 22.5 volts per step.

For voltages from 2 to 150, the 150-volt-range voltmeter on the inclined shelf is selected, and either of two circuit arrangements is used. One, employed for voltages from 40 to 150, is like Fig. 5 except that the 540-volt battery is out of the circuit. For the other, used with voltages from 2 to 40, both the 540- and 180-volt batteries are out of the circuit. For either of these circuits a switch permits reversing the connections to the instrument under test.

For measurements below 2 volts, the millivoltmeter is used, and the circuit

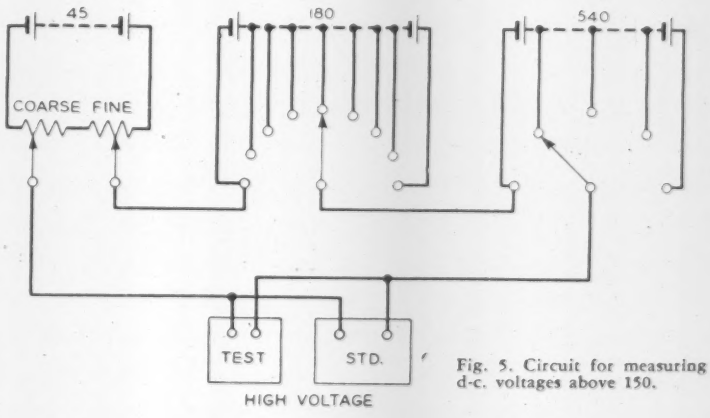


Fig. 5. Circuit for measuring d-c. voltages above 150.

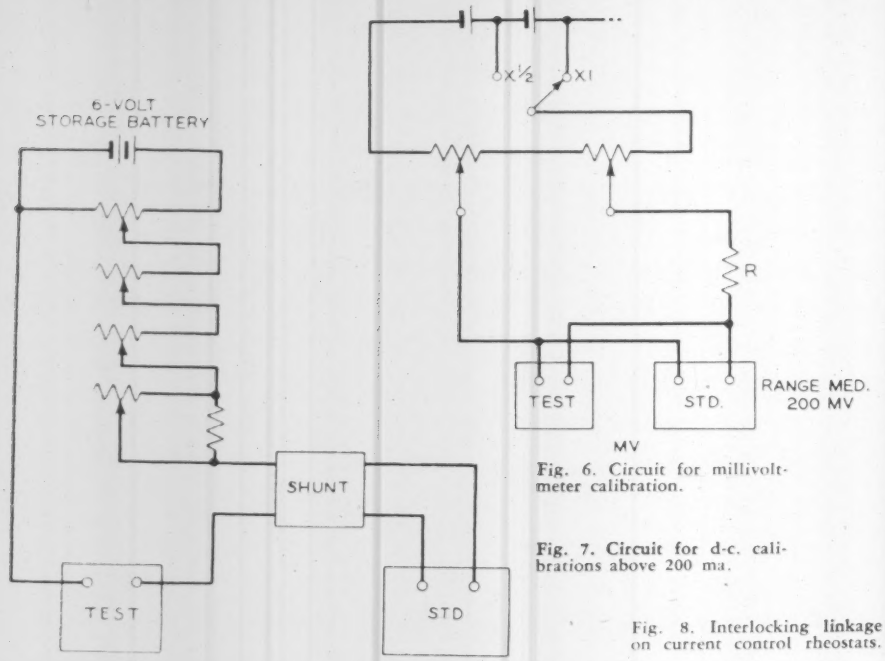


Fig. 6. Circuit for millivoltmeter calibration.

Fig. 7. Circuit for d-c. calibrations above 200 ma.

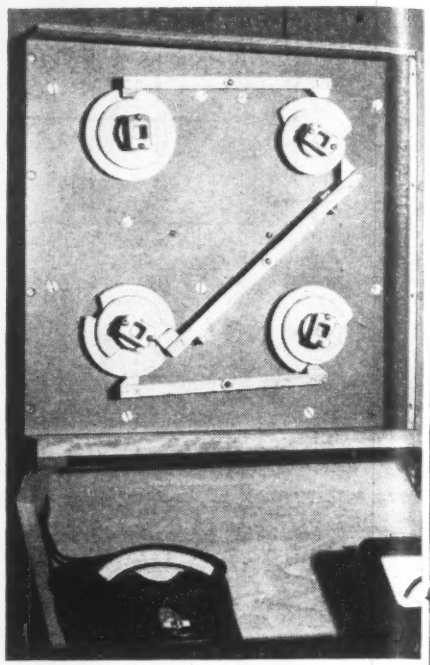


Fig. 8. Interlocking linkage on current control rheostats.

is as shown in Fig. 6. The resistance marked *R* has a different value for each of the three possible ranges using this test circuit, 0 for the 2-volt range, 135 ohms for the 200-millivolt range, and 1,350 ohms for the 2,000-millivolt range. Only the 3-volt battery is used, and connection is made to it through the upper right dial. This is normally kept in the maximum ("×1") position, but a half voltage reading may be obtained by turning it to "×½."

For milliampere calibrations, the circuit is the same as Fig. 6, but with a switch included to permit the connection to the instrument under test to be reversed. Four milliampere points are marked on the range switch: MA-LOW, for currents up to 1 ma.; MA-MED, for currents from 1 to 10 ma.; MA-HIGH (2v.), for currents from 10 to 100 ma.; and MA-HIGH (40v.), for currents from 100 to 200 milliamperes. The circuit for the latter point differs from Fig. 6 in using the 45-volt battery.

For checking instruments at currents greater than 200 ma., a 6-volt storage battery is used as shown in Fig. 7. The shunt is a Weston rotary type controlled by the dial on a narrow panel second from the left. With this dial, any of six shunts (1, 2, 5, 10, 20, or 50) may be selected. The voltage-dividing and series resistors are controlled by the four dials on the left-hand panel. Since compact rheostats with high enough resistance to give fine control for the lower current ranges and capable of carrying the larger values of current were not available, an interlocking mechanism was designed to prevent any combination of settings that would endanger any one of the rheostats. This is shown in Fig. 8. Each rheostat has a different current capacity, and the winding of the lowest-valued resistance, the last in the chain, has a tapered winding. The linkage is arranged so that a rheostat is locked in its "OUT" position before settings of the others can be made that would endanger it. With this arrangement, adequate adjustment is available over the entire range without overheating any of the rheostats.

Beside these various controls used for the actual calibrations, there are pilot lamps to indicate when power is on various circuits, and switches for opening or reversing various circuits. All circuits are completely fused for protection, and the connections between batteries are carried through door switches so that, when the cabinet doors are opened, not more than three 45-volt batteries are connected together.

POSTWAR INSTRUMENT OPPORTUNITIES

Ex-meterman Turns to Watchmaking

MANY watchmakers became instrument maintenance and repairmen in the Armed Forces (and in civilian capacities) during the National Defense program before Pearl Harbor; and many more since then. But what of our future supply of watchmakers?

Clifford T. Johnson, of Glendale, Calif., honorably discharged serviceman who for twelve years serviced meters for the Iowa-Nebraska Light & Power Co., Lincoln, Neb., has chosen watchmaking as his postwar career. One of the first ex-soldiers to take advantage of training offered under the "G.I. Bill of Rights," Johnson is enrolled at the American School of Watchmaking, Glendale, Calif. In the picture above he is operating a Paulson Time Micrometer.

Preventing Moisture-caused Leakage in Electrical Instruments

By LESTER F. BOSS, Curator of Apparatus, Mellon Institute, Pittsburgh

FOR several years the writer was employed at a laboratory located at an exposed place directly on the Eastern shore of the United States. High relative humidity and consequent condensation was a source of considerable trouble in the form of electrical leakage in sensitive electrical apparatus and other moisture-sensitive equipment. As a matter of fact, for extended periods in May and June, moisture condensed on the walls of the lower levels and ran out on the floor. Also, steady fog-laden winds drove moisture throughout the building.

Most of the trouble was due to the temperature of the apparatus being below the dew-point temperature, with consequent condensation of moisture. This occurred mostly in the early morning hours, after the building (and its contents) had cooled, and when warm air of high relative humidity entered the building.

By maintaining the temperature of the apparatus two or three degrees above the ambient temperature, all this trouble was prevented, except in the case of hygroscopic materials. The temperature was maintained above ambient by several means which will be described and which are recommended. The simplest is listed first.

(1) Radiation from a small desk lamp directed on the apparatus overnight. This is satisfactory for small apparatus constructed of heat-conductive materials so that the back will also be above ambient, and so that the temperature gradient will not be a source of trouble.

(2) Heating the room by means of a small *vented* gas flame or electric heater. A few cubic feet of gas per hour or a couple hundred watts are usually adequate. The vented gas heater has some advantages inasmuch as it removes air from the room. Electric heat would be as good if provision was made for the positive admission of a small amount of fresh air. The point here is that moisture from the walls and occupants would tend to raise the relative humidity, thereby defeating the purpose of the arrangement.

(3) Cabinet with a continuous supply of warmed air. The cabinet should have a sliding window front so designed and counterweighted that it may be opened fully for the purpose of setting up apparatus. In use, the window is raised sufficiently to admit the operator's hands and forearms. The air flow is outward, thereby keeping the apparatus completely immersed in warm air.

In cases where warm air is used, either in a cabinet or a room, it is important that the circulation be good. Convection gives satisfactory circulation if the heater is placed low and particularly if a tall stack, such as two or three lengths of stove pipe, is used. An insulated stack connected near the bottom of a cabinet and extending to the floor is quite satisfactory. In all cases the heater should be placed near the lower end of the stack.

Fans may be used to circulate the air, but are usually not necessary and may be objectionable because of the noise.

In applying heaters to instrument cabinets, such as used in rack-and-panel assemblies, it is suggested that a small stack extending nearly the height of the cabinet be used, with the heater placed near the lower end but so located that the contents of the cabinet are shielded from radiation from the heater. This will give good circulation with a minimum of local heating.

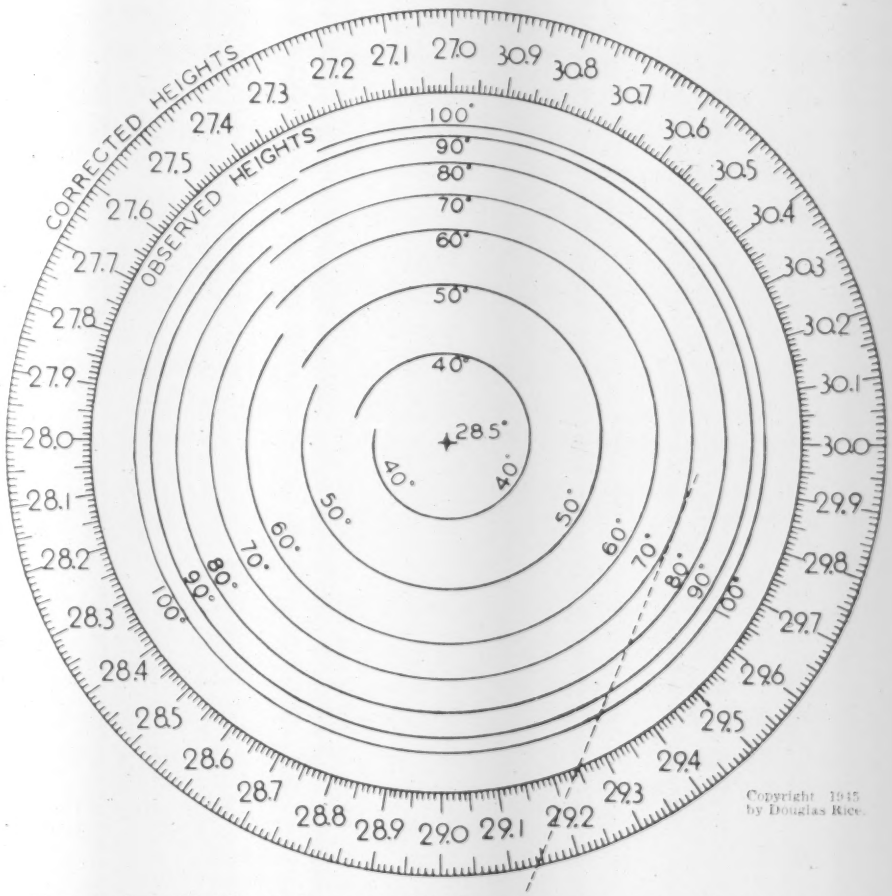
Dehumidification by means of absorption or refrigeration types of units is satisfactory but usually unnecessary.

In general, low humidities are not required, except where hygroscopic materials are involved. It is important that the temperature of the apparatus always be above the ambient temperature. Dehumidification invariably involves a temperature change and should be kept in mind if this means is considered.

Temperature-corrected Readings for Brass-scale Mercurial Barometers

INCHES OF MERCURY AND DEGREES FAHRENHEIT

By G. DOUGLAS RICE, Springfield, Mass.



Corrected reading located on a straight line drawn tangent to the temperature curve and through the observed reading.

Example shown:

$$H_0 = 29.25''; \; T = 70°\text{F.}; \; H_c = 29.14''$$

where H_0 is observed height and H_c is corrected height.

Chart is based on formula:

$$H_c = H_0 - \left[H_0 \times \frac{0.0001001\ (°\text{F.} - 32) - 0.00001041\ (°\text{F.} - 62)}{1 + 0.0001001\ (°\text{F.} - 32)} \right]$$

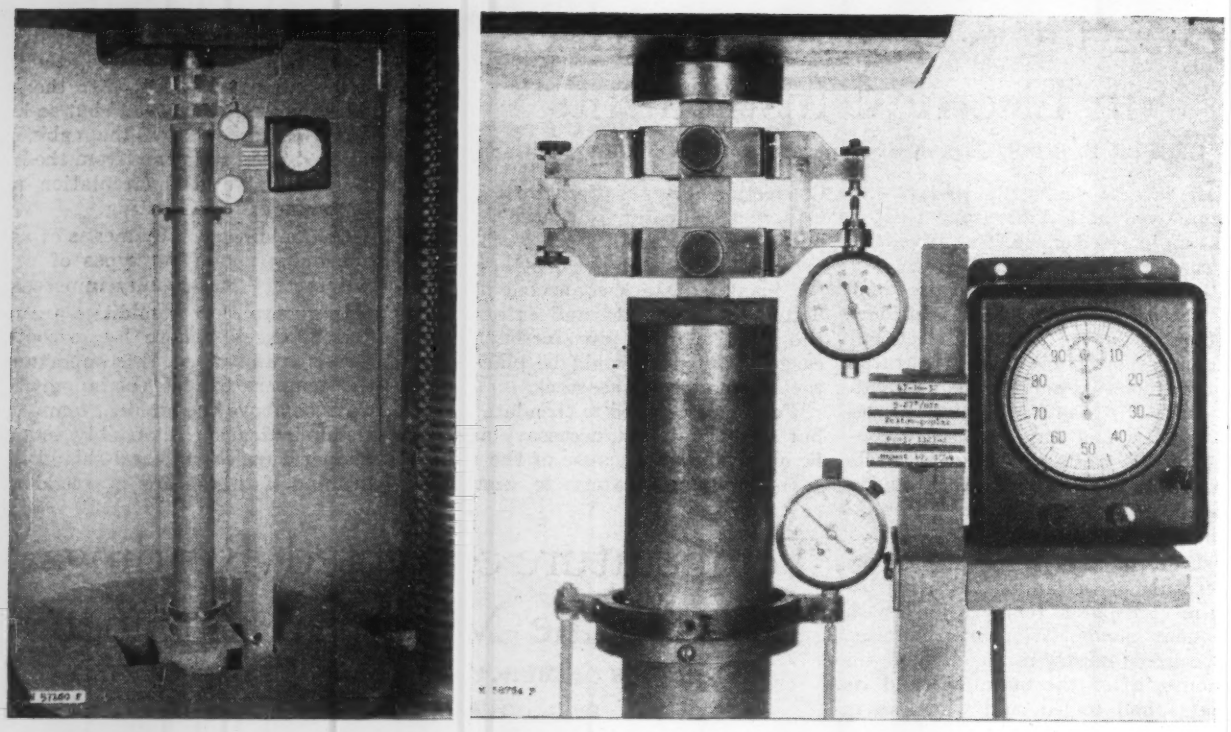


Fig. 1. Load and strain measuring devices showing location of indicating dials, electric timer, placard for inserting typewritten entries, etc.

Load and Strain Measuring Instruments for Use in Rate-of-loading and Constant-load Tests

By G. W. FOSTER, Engineer, Forest Products Laboratory,* Forest Service, U. S. Department of Agriculture

TESTS made at the Forest Products Laboratory, in cooperation with the Army-Navy-Civil Committee on aircraft design criteria, to determine the strength characteristics of wood in compression parallel to grain under high rates of loading necessitated the development of the special load and strain measuring devices shown in Figs. 1 and 2. The equipment was used to measure the effect of rate of loading on ultimate strength, proportional limit, modulus of elasticity, strain at ultimate and at proportional limit of specimens matched to controls tested at standard speed; also to determine the duration of constant loads that were attained by rapid application and which ranged from 94 to 120 percent of the ultimate load of matched control specimens tested at the standard speed.

LOAD-MEASURING DEVICE

The load-measuring device, shown in Fig. 1, consisted of a 3″ diameter steel tube 37″ long with flat bearing caps 1″ thick at each end. Two collars, 30″ apart, were connected by two ¼″ round rods. The collar near the top was rigidly bolted to the tube; the other collar, near the base, pivoted on two conical points. The rods were threaded at each end for attaching to the collars and to a dial indicator mounted on the upper collar. A short length of 0.050″ diameter wire was interposed just above the lower collar in each rod to reduce bending of the rods.

The dial indicator, graduated to 0.0001″, measured the deformation of the tube resulting from the load applied to the specimen.

Calibration of the tube, up to a load of 13,000 lbs., with attached dial, was accomplished by placing known loads on the tube and reading the dial. The calibration, checked frequently during the progress of the tests, remained essentially constant.

STRAIN-MEASURING INSTRUMENT

The strain-measuring instrument, Fig. 2, consisted of two steel yokes connected at one end with a flexure plate

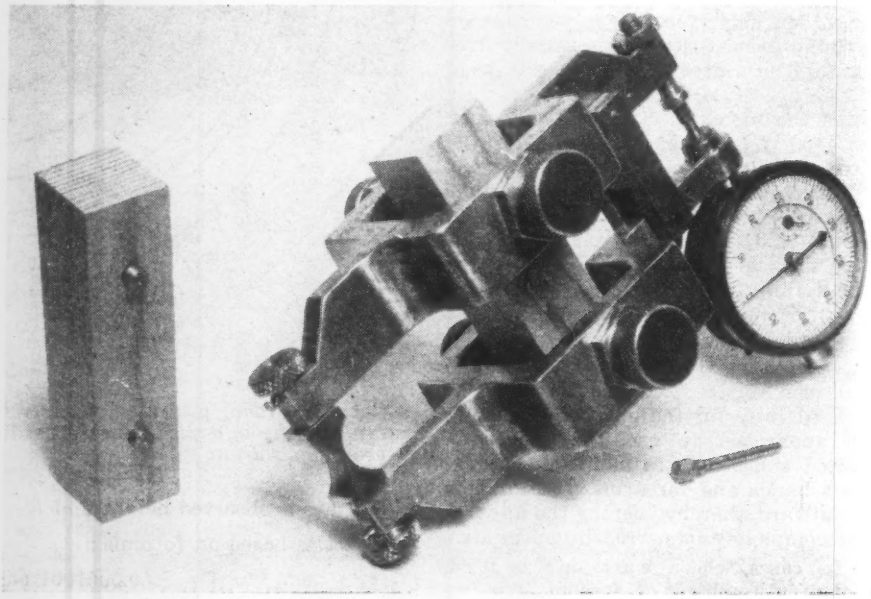


Fig. 2. Strain measuring instrument showing specimen in place and pin removed.

*Maintained at Madison, Wisconsin, in cooperation with the University of Wisconsin.

t free to move at the opposite end. A link connection, attached at one end by a permanent pivot and at the other by a removable pin, served to fix the gage length and to position the two limbs of the instrument with respect to each other during insertion of the specimen. Strain measurements were made by attaching the instrument to the specimen by conical-pointed thumb-screws bearing on small steel pins embedded in the tangential face. A dial indicator, graduated to 0.0001" and secured by a set-screw to the lower bar, measured double the strain over a 2" gage length. The instrument was calibrated by means of an optical comparator.

RECORDING OF DATA

The rapid movement of the dials, due to loading times varying from 30 seconds to ½ second, required the use of a high-speed 35-mm. motion-picture camera for the recording of the data. The camera, which was hand-operated at speeds ranging from approximately two frames per second (for tests lasting 30 seconds) up to 60 frames per second (for the fastest rate of loading) included in its field the load and strain indicating dials, an electric clock reading to 0.01 second, and a placard listing the number of the specimen and other details. The pictures were later read by use of a microfilm viewer, and the data were tabulated and plotted.

Coil and Scale Rating Relations in Alternating-current Instruments

By PAUL MacGAHAN

BETWEEN the nominal coil ratings and the full-scale values of alternating-current instruments there are some definite relations; but they are not always self-evident. It is the purpose of this article to make these relations, and their reasons, more clearly understood by the users of a-c. instruments.

First of all, the full-scale marking of an instrument is *not necessarily* the same as the rating of its coils.[1] Most a-c. power circuit instruments operate from the secondaries of instrument transformers; some, however, operate directly from the measured circuit; but even in the case of the latter, the carrying capacity or rating of the coils may differ from the full-scale marking of the dial.

As exemplified in Fig. 1, the nominal ratings of the coils are generally specified by notations in small type on the dials or the name-plates, and in the manufacturer's catalog listings.[2] People don't like to read small type, but please note that there are ten notations on the Fig. 1 dial: if they were enlarged, the appearance of the dial would be spoiled.

In the case of ammeters or voltmeters the relation between the coil rating and scale marking is readily shown by the dial notations: in most cases the coil capacity is the same as the full-scale, or as the full-scale divided by the transformer ratio in the case of transformer-operated instruments.

The *nominal* rating of the coils or circuits in an instrument must however be designed to be equal to, or less than, the *maximum* current or voltage to which they may be continuously subjected without exceeding their permissible temperature rise.[3] This rating may be much less in special applications.

In wattmeters and power factor meters (as well as in watthour meters which are not "instruments"), there is no direct relation between the amperes or volts and the watts. For any given value of watts, the amperes or volts, or both, may be almost anything, depending upon circuit conditions. Very well, let us take up these conditions one by one.

[1]ASA Instrument Specification C-39 (4.1)
[2]ASA Instrument Specification C-39 (7.8)
[3]ASA Instrument Specification C-39 (4.2)

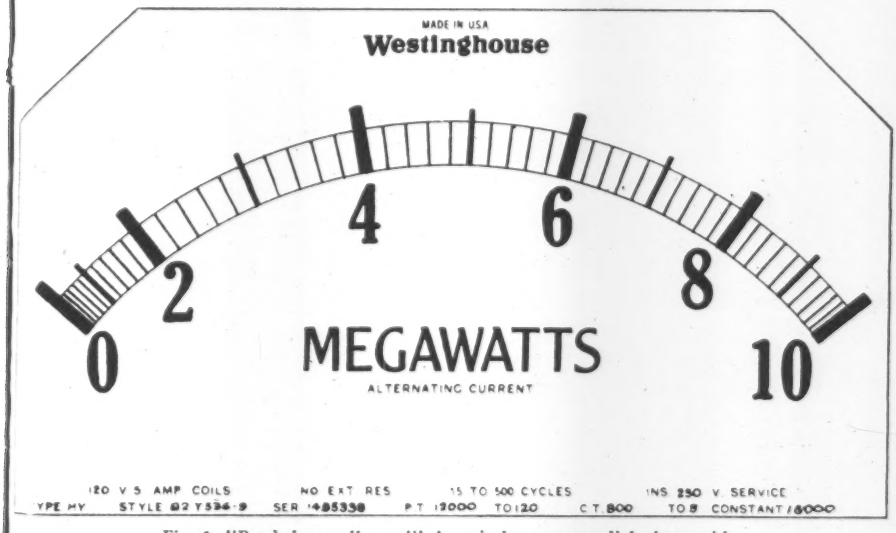


Fig. 1. "Read the small type!" A typical wattmeter dial plate, with coil rating and calibration data notations. (15/16ths actual size.)

AMMETER CONDITIONS.

The nominal rating of an ordinary ammeter is usually its full-scale marking, and the coil must be designed to carry the load continuously.

In special cases the coil may be different, as in the case of a circuit where it is intended to show momentary overloads while using a current transformer equal to the continuous rating of the line.

However, whatever current transformer ratios are used, it is self-evident that the amperes in the coil per ampere on the scale must agree with the ratio of transformation.

The usual secondary current rating of current transformers is 5 amperes. The primary may be any standard value which will carry the measured circuit satisfactorily. Ordinarily, but not always, this primary rating will be the same as the full-scale marking of the ammeter, in which case the full-scale coil current is obviously 5 amperes. In other cases it may be desired to have the ammeter read higher currents momentarily; or in special cases continuously. In these cases the full-scale coil current is no longer 5 amperes. Where the distance between the instruments and the transformer is very long, current transformers with one-ampere secondaries have been used.

For example, if in an ammeter the scale is marked zero to 500 amperes and the instrument is intended for use with a 500/5 current transformer (ratio 100:1) it is obvious that full scale deflection will be obtained with 5 amperes in the coil. Thus, in this first example, *the coil rating is 5 amperes.*

For our second example we shall assume that for some reason peculiar to the installation, an ammeter having its scale marked 0 to 500 amperes is intended for use with a 500/1 current transformer. Then, full-scale indication will be obtained with one ampere flowing through the ammeter. *Thus the coil rating is 1 ampere.*

For our third example we assume

that in some specific installation it may be necessary to use a 500/5 ampere current transformer (ratio 100:1) and that the transformer will never be operated with over 300 amperes through its primary. In such an installation, it probably would be well to use an ammeter having a full-scale marking of 300 amperes. In this particular installation, then, since the secondary of the current transformer will deliver only 300/500 of 5 amperes, or 3 amperes, *the coil rating of the ammeter is 3 amperes.*

In the examples thus far, it may be seen that the coil rating can be expressed as follows:

$$\frac{S}{P} \times R_{FS} = R_c$$

where S is the transformer secondary current, P the transformer primary current, R_{FS} the instrument full-scale rating and R_c the coil rating.

In the first example:

$$\frac{5}{500} \times 500 = 5$$

In the second example:

$$\frac{1}{500} \times 500 = 1$$

In the third example:

$$\frac{5}{500} \times 300 = 3$$

DESIGN CONDITIONS.

For dynamic and mechanical reasons the relation between spring strength (which is the same as the electrical force on the movement) and the weight and inertia of the movement must be maintained within close limits. Therefore the spring strength or torque of the moving element or coil cannot be largely altered. For example, a 5-ampere instrument cannot be made into one of 8 amperes or 4 amperes by merely substituting a different spring. To do so would entirely upset the damping factor and friction-compensation effects.

Now it may happen in the third example above (3-ampere coil) that the current transformer occasionally would reach a value of 325 amperes and that it would be necessary to have the ammeter indicate this maximum value. Quite obviously, then, the *scale* must be greater now than 300 amperes. At first thought it might be judged that the best thing to do would be to provide the ammeter with a scale marked zero to 330 amperes and to use a 3-ampere coil. However, a 330 scale marking cannot be made with division lines and figures that would be easy to read. Furthermore, there may be no stock size or factory routine to wind a coil for 3.3 amperes in the shape of coil required. (It's hard enough to train coil-winders and keep them, without expecting them to be mathematicians!) Therefore some compromise is in order. It is desirable that the instrument have a scale range of such value that the pointer will normally deflect well upscale. At the same time, since our ammeter must have a scale which can be easily read (1, 2, or 5 of the units read or any decimal multiple of same[1]) it would probably be best to select a range of 0 to 400 amperes. In manufacture, however, it may happen that there is no standard 4-ampere coil available. Now, since a 3½ ampere stock size coil will easily carry 4 amperes, the simplest solution is to take the 3.5-ampere coil and to provide a stronger spring, so that with 4 amperes in the coil the ammeter will deflect to full-scale. Thus the requirements of the installation are met, at the expense of the ideal or best mechanical performance. The coil rating, now, is therefore not as given by the equation. The complete story as shown by the dial data markings would be:

Ammeter, with scale 0-400 amperes, for 500/5 current transformer.
Coil rating = 3.5 amperes.
Full-scale rating = 4 amperes.

(Actually, thermal capacities in current coils of well-made instruments are so liberal that they may be operated continuously with ample overload margin well over normal or nominal rating.)

WATTMETER CONDITIONS.

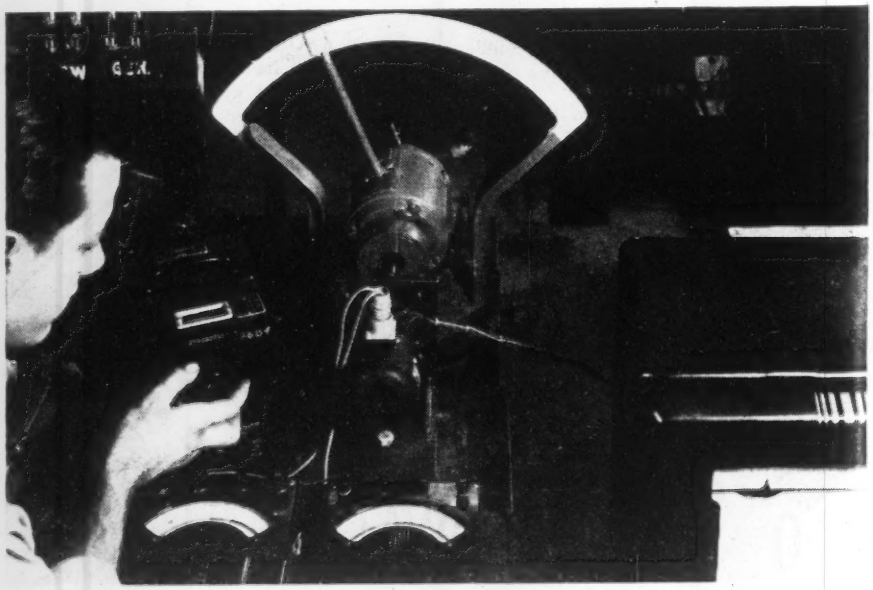
The coil and scale rating relations in wattmeters are quite different from those in ammeters or voltmeters, because wattmeters (and power factor meters) contain both current coils and voltage coils, reacting upon each other. A wattmeter is an electrical form of dynamometer. It measures electrical power directly by producing electromagnetic forces. It does not merely multiply amperes by volts. The currents and voltages applied to a wattmeter may vary independently of full-scale or

[1]ASA Instrument Specification C-39 (7.2)

Instruments in the War Effort

Testing Motors at 30,000 R.p.m

TO help analyze the performance of small high-speed motors for airplanes, Westinghouse small-motor designers have built their own test dynamometer because dynamometers suitable for testing motors and generators at 20,000 r.p.m. were not available. The new high-speed dynamometer is capable of testing machines of 1/100 to ¾ h-p. and is frequently operated at speeds up to 25,000 r.p.m. It has been run as fast as 30,000 r.p.m. but no attempt has yet been made to determine whether it can be safely run at higher speeds. The



dynamometer is of the conventional cradle type, but using special low-lo s steel in the armature and embodyi g every known expedient to provide hi h bursting strength. It is a laboratory i strument: no commercial models.

er power values as variations occur in power factor, voltage, phase angle, or wave-shape conditions, or system connections. The electromagnetic measuring forces or torques may thus be the result of high-current-and-low-voltage or low-current-and-high-voltage, and of phase conditions. (The expression power = amps × volts × cos ϕ is merely a mathematical form.)

The electrodynamic mechanism of a wattmeter has no ability to distinguish between separate components which combine to create the force. Therefore the scale range of a wattmeter has no relation to the separate current-coil or voltage-coil ratings or to the separate values of amperes or volts which may be present.

Referring again to Fig. 1, it will be seen that in addition to the nominal capacity ratings of the coils, data are given on the ratios of the current and the potential transformers, resulting in the calibration constant K. The constant K in a self-contained instrument is of course 1. In a transformer type wattmeter it is the product of the separate ratios of the current transformer and of the potential transformer. It is equal to the kilowatts (or kilovars) indicated per kilowatt applied to the coils on a single phase test circuit. This will be made clear by the following examples:

Example 1.

A left-zero 3-phase 3-wire polyphase wattmeter for use with 800/5 (160:1 ratio) current transformers and 12000/120 (100:1 ratio) potential transformers.

Full-scale capacity desired, 10 megawatts (10,000 kw.)

Calibration Constant, K, $160 \times 100 = 16000$.

Therefore, watts applied to coils, $10{,}000{,}000/16000 = 625$.

Polyphase wattmeters are calibrated on single-phase circuits. As the polyphase vector relations between line currents and the voltages appear equally in both the primary and the secondary circuit, these vector relations (30° between currents and voltages on 100% power factor of a three-phase circuit) do not affect the calibration, and may be disregarded. (An exception to this is the case of the 3-phase 4-wire three-current-coil wattmeter, sometimes referred to as the 2½-element wattmeter, in which the calibration on single-phase test circuits is different from that on 3-phase 4-wire connections).

In the above example, as there are two elements pulling together, each requires 312.5 watts (625/2). Assuming the single-phase test circuit condition, this requires $312.5/120 = 2.6$ amperes (approx.) Let us assume that the nearest stock standard coil is one rated at 3 amperes. Calibration is adjusted to agree with the required constant K by the adjusting means provided in the design. This 3 amperes is the current coil rating given on the dial data lines or on a name-plate.

Example 2.

A center-zero wattmeter, otherwise same as in Example 1.

Capacity 10-0-10 megawatts.

Watts full-scale 312.5 each element, and amperes full-scale 2.6 as before.

As the spring deflection is only half-scale, the spring must be of the same strength as previously explained: it requires only half the ampere-turns in the current coil to give full-scale deflection. As all standard coils are made with the same ampere turns, this means that instead of a 3-ampere coil, a 6-ampere coil is used.

In certain cases, owing to the full-scale and transformer ratios desired, it is not possible to choose a coil of sufficient current-carrying rating as given in the above examples, as that would require either too weak a spring for best action or too low a resistance in series with the voltage coils, thus introducing electrical errors. The following example will serve to illustrate this condition.

Example 3.

Wattmeter for low (25%) power factor circuit.

Full-scale required, 125 watts.

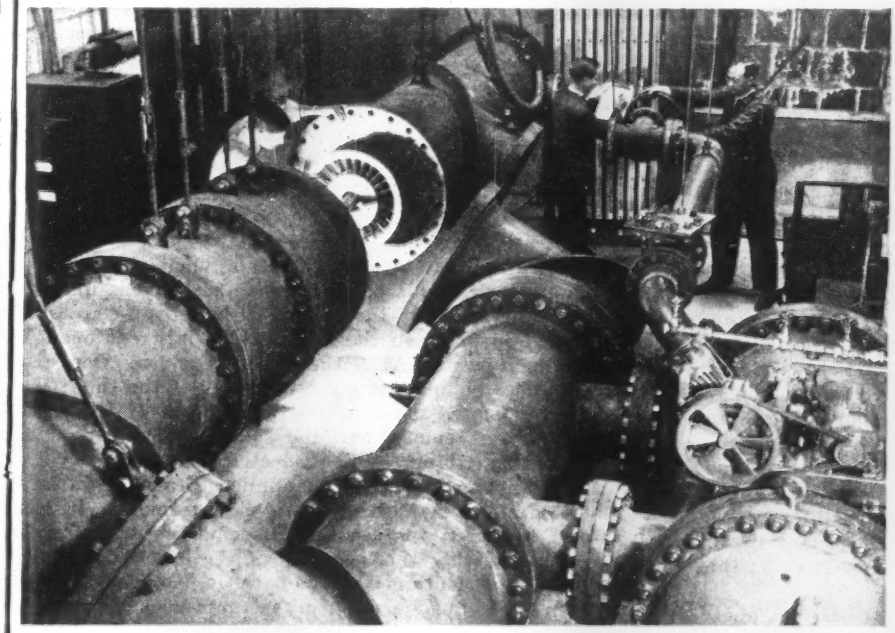
Normal coil current, 125 watts/120 volts = 1.04+ amperes.

Normal line current at 25% power factor $1.04/0.25 = 4.16$ amperes. If a 5-ampere coil were used, it would be necessary to reduce the voltage circuit resistance to a dangerous degree in order to get sufficient operating torque. Thus a design compromise is necessary. In this case, therefore, one should use a 3-ampere coil, a weaker spring, and a lower series resistance, so as to distribute the errors. The coil data as marked on the instrument would then be 3 amperes. Distribution of the error possibilities gives a lower probability of error. After all, all good design is

Continued on page 116

Turbine-blade Tests Speeded

SHOWN here is a general view of a new high-pressure type of wind-tunnel which tests the blades of Westinghouse turbines many times faster than is possible with earlier types of tunnels. The wind tunnel used heretofore provides information on the aero-



dynamics of blades under high gas-velocities and gives the accurate answers needed for final designs, but: (1) models must be carefully made of steel and (2) the wind-tunnel itself is massive and requires a great deal of power to drive it. Consequently, seldom can as many as a half-dozen tests be made in a year with it.

The new tunnel, on the other hand, tries the blades at low speed but in a medium of high pressure (220 lbs./in.^{2} instead of atmospheric) so that the models can be fashioned of wood. Variations in shape and position can be tried in a few hours instead of weeks.

This type of testing is possible because the air-flow data are acceptably accurate if the pressure is increased as the speed is decreased, in such a ratio that the Reynolds number is unchanged. For velocities well below that of sound (i.e. where compressibility is not a factor) the results obtained with the high-pressure tunnel are accurate within limits required in preliminary studies. This allows many variations to be tried quickly, greatly expediting the final designs, which can then be tested by the slower but more precise high-speed tunnel.

ELECTRIC GAGING METHODS for Strain, Movement, Pressure and Vibration

By HOWARD C. ROBERTS, Research Staff, Association of American Railroads, Chicago, Ill.

VI. MISCELLANEOUS ELECTRIC GAGING METHODS

§ 1. General

Among the several types of miscellaneous electric gaging methods (those based on principles other than the three fundamental circuit parameters) may be found methods utilizing almost all of the observed electrical effects. Those in widest use are represented in this list:

1. Photoelectric or electro-optic;
2. Piezoelectric or electrostrictive*;
3. Acoustic; and
4. Thermoelectric.

Others, of perhaps equal importance but not directly classifiable, have also been used.

A remarkable variety of forms of pick-up devices may be found in this miscellaneous catagory, and the applications to which they have been put are also most varied. Few have found wide acceptance as individual systems, although some of the operating principles are widely used. Many show promise for wider use than they have yet received.

§ 2. Photoelectric and Electro-optic Systems.

The basis of all photoelectric measuring systems is the response of the photoelectric element to radiant energy. Any photoelectric tube or cell may be considered (in this discussion) as a source of electric potential or current whose value depends upon the amount of radiant energy collected by the sensitive surface.

A number of different photoelectric elements are available; the emissive, the conductive and the generating types are all in common use. The emissive and the conductive types require a source of polarizing or operating potential, while the generating types do not. Not all elements have the same response to light of different colors—or to infra-red or ultra-violet radiation—so the color of light may be analyzed by a photoelectric device.[221]

Photoelectric systems can therefore be employed to measure any magnitude which can be presented to the system as a varying light intensity, quantity, or color.[222]

The simplest of these devices are no more than on-off devices; with them doors can be opened, labelled tins segregated from unlabelled ones, spotted beans from white, and a multitude of other similar tasks performed. Only slightly more refined systems are required to sort articles differing in minor respects. Others of the same general form control printing processes so that successive impressions of different colors will register properly, and control wrapping machines so that the position of the pattern on the wrapper is the same for all wrapped articles.[223,224] Still others count articles, distinguishing between items of different size, color, or texture. But these things, while extremely useful, are detectors of presence, and in a limited way quality; they are hardly measuring devices.

An obvious extension of the application of the photoelectric unit is its use to detect the incidence of a movement. Such devices are used as limit controls to stop the travel of a machine carriage, as devices to govern the feed and depth of cut of a machine tool, and as safety devices to stop the motion of a machine if the operator's hands enter a danger zone.[223,225]

If the movement of the light impinging upon the photoelectric cell is properly harnessed, many other measurements can be made with the simple on-off system. The depth of the heavy sludge at the bottom of a coal-washery tank has been controlled by the motion of a vane attached to a float which is too heavy to float on the water but too light to sink in the sludge. The photoelectric unit may be caused to observe the motion of this vane, and to control a waste gate, so that the depth of the sludge is kept at the optimum value,[226]

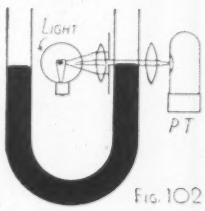


Fig. 102

The level of the mercury, or other opaque liquid, in a transparent U-tube manometer may be guarded by a similar installation. In Fig. 102 the arrangement of the parts of such an installation is sketched. If the electric circuit and the mechanical arrangement are refined to afford continuous indication, the actual level may be indicated or recorded.[227]

Transparent liquids in sight-glasses are not quite so easily watched, unless the refractive power of the liquid is employed instead of its opacity.[228] If a beam of light is directed at a point near the periphery of the tube rather than along a diameter, the beam will be deflected when the tube is filled with liquid, but not appreciably when the tube is empty. When refracted, the beam of light strikes the photoelectric cell. This action is illustrated in Fig. 103;

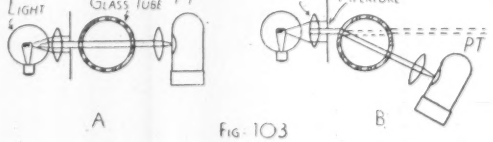


Fig. 103

at *A* is shown the path of the light beam when it is directed along a dameter. In this configuration the beam is undeviated by the presence of the liquid—although of course in the practical installation the beam width is great enough that dispersion occurs. At *B* the action is shown when the light beam does not pass along a diameter of the tube; the dotted line indicates the nearly-straight path of the light when the tube is empty, and the solid line indicates the refracted path, striking the photoelectric tube *PT*.

This on-off principle has been applied to a wide variety of control functions, and to many measurements. It has been used to locate the position of leaks in drilled well bores,[229] by detecting the locations of the less opaque portions of the fluid contained in the bore. It has been used to inspect sheets of opaque material for pin-holes,[223] and to inspect jig-saw puzzles for missing pieces. In the steel mill, its applications include the control of flying shears, the strip-width measuring device, the sheet slitter, and the loop-

*The electrostrictive effect is often confused with the piezoelectric. The piezoelectric effect is peculiar to anisotropic materials; the electrostrictive effect has been found in such materials as glass, rubber, etc.

(221) Raymond Jonnard, Practical Color Photoptometry. *Instruments*, Vol. 17, 1944, pages 474, 500.

(222) W. D. Cockrell, Industrial Electronic Control. McGraw-Hill Book Co., New York, 1944. 250 pages.

(222A) R. C. Walker and T. M. C. Lance, Photoelectric Cell Applications. Pitman Publishing Corp., New York, 1938. 336 pages.

(223) Harold J. Hague. Electrons at Work. *Radio News*, Vol. 32, December 1944, pages 40, 41, 108, 110, 112.

(224) D. R. Shoults. Applications of Photoelectric Register Control. *General Electric Review*, Vol. 37, 1937, pages 170-174.

(225) George Schlesinger. Modern Measuring Instruments and Principles of Their Design. *Machinery* (London), Vol. 57, 1940, pages 12-17 and 37-40.

(226) H. H. Slawson. Photoelectric Control of Sludge. *Electronics*, Vol. 14, October 1941, page 72.

(227) J. M. Weinberger, Electronic Flow Meter. *Electronics*, Vol. 14, January 1940, pages 30-31.

(228) N. H. Ceaglske and S. A. Kesslinger. Photoelectric Automatic Liquid Level Control. *Industrial and Engineering Chemistry* (Analytical Edition), Vol. 16, 1944, pages 393-394.

(229) C. A. Heiland, Geophysical Exploration. Chapter I. Prentice-Hall, Inc., 1940, 1,000 pages.

sa control.[230] The depth of the loop of material between two stands of rolls must be kept constant for best operation; if this loop is guarded by a photoelectric device, an indication will be made when the depth of the loop changes. The arrangement is shown in the perspective sketch of Fig. 104.

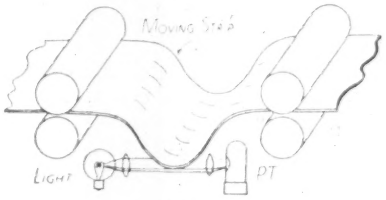


Fig. 104

The arrangement comprising the strip-width gage is shown in Fig. 105; here two photoelectric tubes (and two light sources) are used, one at each edge of the sheet. When the edge of the moving sheet moves out, and encroaches upon

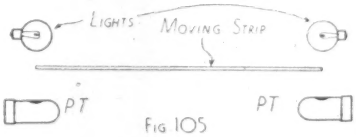


Fig. 105

the light beam at one side or the other of the installation, an indication is given. With both of these equipments, the output of the phototube circuit is usually fed into a control system. There are many other applications for such units as these, both published and unpublished; they range from the opening of a door at the arrival of a vehicle to the inspection of filled soft-drink bottles to detect foreign bodies.[231] This latter is an unusually clever mechanical set-up, in that the bottles are whirled to agitate the contents and the light source and photoelectric unit are moved along with the bottles, at the same rate of speed, while the inspection is being made. Another sort of measurement easily performed is the counting of pulses or flashes of light. This ability is often employed in counting the revolutions of rapidly rotating parts, or of inaccessible parts.[232] A somewhat similar set-up has even been used to count and record the intensity of firefly flashes![233]

Extension of the simple on-off principle to the measurement of degree or intensity is an obvious one; it requires only the replacement of the relay in the electric circuit with an indicating instrument. The on-off circuits do in one sense measure intensity, since they are customarily adjusted to operate only after a threshold value is exceeded. A circuit able to respond in both manners is shown in Fig. 106; the

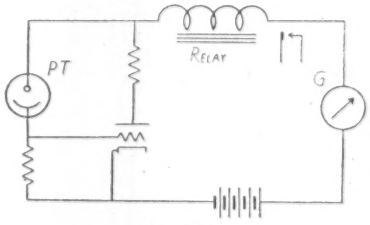


Fig. 106

relay in series with the indicating instrument does not interfere with the operation of the instrument, nor does the measurement of the plate current of the electron tube interfere with the operation of the relay.

With the ability to measure intensities of light, an entire new series of possibilities becomes available. Almost any movement may be converted into a variation in light intensity, either by changing the width of a slit or otherwise; it is then possible to convert the variation in light intensity into a variation in an electric potential or current, which can be easily measured. In physiology, measurements of muscular contraction and of blood pressure are so made.[234] In electrical engineering, the operation of line selector relays has been studied.[235] Strain gages of extremely short base-length have been constructed by employing a lever system to transfer the movement to the jaws of an optical slit—usually with some mechanical magnification—where it changes the width of the slit and therefore the amount of light passed through it to the photoelectric cell.[236] Another mechanical form of this gage employs a pair of multiple slits or parallel gratings.[237] The action is the same in both circuits: the percentage change in the amount of light transmitted is equal to the percentage change in slit width, whether a single slit or a multiple-slit arrangement is used. The operation of the gage may be understood by referring to Fig. 107.

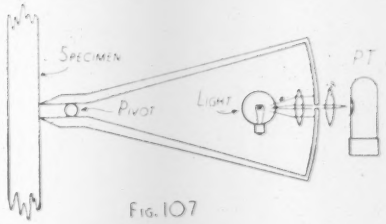


Fig. 107

Torsional displacements may be similarly measured, either by the use of angular apertures or polarizing devices.

A number of industrial devices, some representing a high degree of refinement in design and construction, employ this general method. Several different optical arrangements have been used.[238] Such devices are capable of high sensitivity and rapid operation, and if well constructed are accurate and reliable; for accurate performance over long periods of time considerable care must be exercised in their construction. In the automobile industry these methods have been found of great value in the automatic adjusting of spark-plug gaps, the testing of mechanical parts, and the gaging and sorting of accurately-machined parts.[239]

The change in light intensity may be produced by the *conditions* at a surface or in a space, rather than by a mechanical movement. Turbidimeters and smoke-density meters are examples of the first of these applications; ultraviolet illumination is used to detect the presence of gases or vapors invisible to visible light.[240] The smoothness of mechanical surfaces can be compared by the amount of light reflected from them—the measurement indicates the amount of diffusion which has occurred. A more elegant method employs two parallel beams of light reflected through a cylindrical lens to form a highly astigmatic image of the point source.[241] This method can detect extremely small irregularities, and the equipment is simple and rugged. It may be used visually. In the radio-frequency heating process by which electrolytically deposited tin is

(230) J. O. Campbell. Special Electrical Applications in the Steel Industry. *Iron and Steel Engineering*, Vol. 19, February 1942, pages 78-89.

(231) S. R. Winters. Electronic Bottle Inspection. *Electronics*, Vol. 17, May 1944, pages 156 and 159.

(232) Helmer Dahl and Odd Dahl. A Low Velocity Oceanographic Current Recorder. *Review of Scientific Instruments*, Vol. 9, 1938. pages 243-245.

(233) Charles Butt and R. S. Alexander. Method for Recording Low-Intensity Flashes of Light. *Review of Scientific Instruments*, Vol. 13, 1942, pages 151-153.

(234) W. E. Gilson. Applications of Electronics to Physiology. *Electronics*, Vol. 16, January 1943, pages 86-89, 206.

(235) Anon. Ueber eine spezielle Anwendung der Photozelle zur Aufzeichnung von kleinen Bewegungen. *Zeitschrift fuer Fernmeldtechnik*, Vol. 15, pages 77-78.

(236) E. Lehr and H. Granacher. Dehnungsmessgeraete mit sehr kleiner Messtrecke. *Forschung auf dem Gebiete des Ingenieurwesens*, Vol. 7, March-April 1936, pages 66-74.

(237) C. W. Gadd and T. C. Van de Grift. A Short Gage-length Extensometer and its Application to the Study of Crankshaft Stresses. *Journal of Applied Mechanics*, Vol. 9, 1942, pages A15-A21.

(238) Clifton Tuttle and W. Bornemann. A Method of Dimensional Gaging with Photoelectric Cells. *Instruments*, Vol. 12, 1939, pages 67-70.

(239) R. A. Powers. Tubes Enter the Automobile Plant. *Electronics*, Vol. 8, 1935, pages 276-279.

(240) Anon. A PE Tube Gas Detector. *Electronic Industries*, Vol. 3, March 1944, pages 108-109.

(241) Clifton Tuttle and R. Cartwright. A Method of Measurement of Flatness of Polished Surfaces. *Journal of the Optical Society of America*, Vol. 30, 1940, pages 348-350.

smoothed, a photoelectric device is used to control the input of electric energy to insure optimum performance.[242] And the measurement of transmission and reflection coefficients is well established; this technique has been applied to the measurement of thickness of paper and other semi-opaque materials,[243] to the measurement of transmission of light through the fluorescent screens of television picture tubes,[244] and to such other varied measurements as the suffusion of blood in the skin and the distribution of light in the ocean.[245] It has recently been suggested that the continuous gaging of hot metal strip during the rolling process could be accomplished by using a beam of x-rays and an ionization chamber to replace the light source and the photoelectric tube or cell.

In a most interesting and useful application of the photoelectric principle, the deformation of a diaphragm was used as the criterion of the fluid pressure causing the deformation. A polished metal diaphragm was installed in the cylinder head of an internal combustion engine: the cylinder pressure made it bulge—as shown in the dotted lines in the drawing, Fig. 108—with the result that a collimated

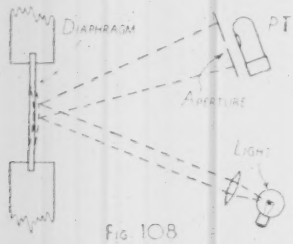


Fig. 108

beam of light was diverged when reflected from it. The intensity of the light thus reflected was diminished as the divergence increased; it was measured by the phototube *PT*. With this equipment measurements of cylinder pressure could be made without any mechanical contact with the engine, thereby avoiding disturbances from vibration. The arrangement was found to respond well even at extremely high frequencies, in engine-indicator studies.[246]

The deformation of a diaphragm has also been measured by the deflection of a beam of light from a small plane mirror attached to it.

The same optical principle has been applied to the surface inspection of bearing rollers.[247] The image of a line source of light is focused on the polished surface of the roller, and the reflected light is in turn focussed on a pair of photoelectric tubes connected to measure ratios of light intensity. The roller is rotated while in this fixture, and any irregu-

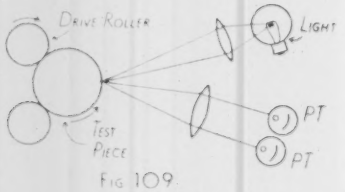


Fig. 109

larity in contour or texture will produce an output from the photoelectric circuit. Fig. 109 shows the arrangement of parts used.

It is desirable to perform such a measurement in terms of the *ratio* of light intensities, whenever possible. If a measurement of a single *intensity* is made, variations in its source will introduce error. But by making the measurement in terms of a ratio, such variations will not affect the accuracy. One arrangement by which a mechanical movement may be converted to a light ratio is shown in Fig. 110. Here two slits are used, so arranged mechanically that as one is opened, the other is closed. For extremely small mechanical movements, multiple slits or gratings may be

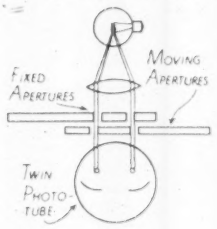


Fig. 110

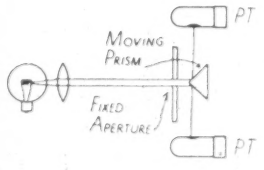


Fig. 111

used. A similar arrangement, using a single phototube, is used for amplifying galvanometer deflections and in automatically-balanced potentiometers.[248] Another method, employing a right-angle prism, has been used for measurements of small displacements.[151] In some applications the prism is made fixed, while the light-beam is moved by the galvanometer. In others, as in Fig. 111, the prism itself is moved. It will be noted that in this arrangement two phototubes are used, introducing the problem of maintaining their sensitivities equal. In the arrangement of Fig. 110 a single twin-type phototube is used. Since this device is simply two electrode assemblies within the same envelope and surrounded by the same atmosphere, such changes in sensitivity as do occur are likely to be common to both electrode assemblies. Drift with phototubes is not a serious source of difficulty.

Of the numerous applications of photoelectric methods to measurements and to servo-systems, the curve-following devices are perhaps the most interesting. These devices follow a chalk line drawn on a steel plate and command machines which cut with an oxy-acetylene flame along that line,[249] or follow a projected performance curve and adjust the controlled equipment in accordance with that curve,[250] or can follow, duplicate, and integrate the most complicated experimental curve.[251] The converse of this action is provided by a recently released device, the odograph, which traces out on a map the route traversed by the vehicle carrying the instrument.[252] In the odograph, a servo-system actuated by a magnetic compass carrying a mirror is one of the controlling mechanisms.

By suitable optical and electrical systems, photoelectric equipment is capable of measurement of factors and magnitudes almost impossible to approach in any other manner. Devices have been constructed which count continuously the threads in a web of woven material, and adjust the speed of the rollers driving it, so that the cloth is made uniform in texture and wound with no weft threads askew. Others have been used to measure, integrate and record the diameter of thread;[253] without some such control it is hardly possible to process many materials.

One unusual but quite powerful method, the petoscope, makes it possible to scan a surface for defects, or an area for moving objects. The basic arrangement of parts is shown

Continued on page 102

(242) D. Fidelman. Photoelectric Control of Manufacturing Operations. *Radio-Electronic Engineering* (Radio News), Vol. 3, December 1944, pages 3-6, 40-42.

(243) F. Sawford. U. S. Patent No. 1,882,962.

(244) Eugene Goddess. Quality Engineering in Tube Manufacture. *Electronics*, Vol. 17, November 1944, pages 134-137.

(245) Horace H. Poole and W. R. G. Atkins. Further Photoelectric Measurements on the Penetration of Light into Seawater. *Journal of the Marine Biological Association*, Vol. 15, 1928, pages 455-483.

(246) A. F. Robertson. An Electro-Optic Pressure Indicator. *Review of Scientific Instruments*, Vol. 12, 1941, pages 142-148.

(247) John H. Jupe. The Application of Electronics to Industry. III. Measurement. *Electronic Engineering* (London), Vol. 14, 1941, pages 492-493.

(248) C. O. Fairchild. Photoelectrically-balanced Recording Potentiometer. *Instruments*, Vol. 7, 1934, pages 58-59.

(248A) C. O. Fairchild. Industrial Temperature Instruments Employing Electronic Methods and Devices. *Instruments*, Vol. 17, 1944, pages 468-472, 496.

(249) Anon Electronic Control of Gas-Cutting Machine. *Electronics*, Vol. 16, December 1943, pages 172, 174, 176, 178, 180, 182, 184, 186.

(250) John Fies. Photocell Control Executes Predetermined Hydro Operation. *Electrical World*, Vol. 102, September 23, 1933, pages 396-398.

(251) Philip Pavda. An Electronic Curve Tracer. *Electronics*, Vol. 16, February 1943, pages 87-90, 202.

(252) D. J. Faustman. Automatic Map Tracer for Land Navigation. *Electronics*, Vol. 17, November 1944, pages 94-99.

(253) [U. S. Testing Co., Inc.] Thread Diameter Continuous Recorder and Grader. *Instruments*, Vol. 9, 1935, page 920.

ELECTRON TUBES—Their Principles and Their Instrumentation Applications

By ANDREW W. KRAMER, Managing Editor, *Power Plant Engineering*, Chicago, Ill.

XXXII. CATHODE-RAY ACTION

(Continued)

Cathode-ray Tube Applications

The principal application of the cathode-ray tube in measurement work is as an oscilloscope, that is, for the observation and analysis of alternating-current waveforms. Its advantages in this field depend upon two outstanding characteristics: (1) a voltage may be measured (if electrostatic deflection is used) without taking power from the circuit under test; and (2) it will follow voltage changes having frequencies of 100 megacycles or faster. With magnetic instead of electrostatic deflection, current rather than voltage determines the deflection and hence power is consumed. The inductance of the deflecting coils also limits the frequencies which can be measured. For these reasons, therefore, electrostatic deflection is ordinarily used for exacting measurement purposes.

An oscilloscope is essentially a cathode-ray tube with connections such as are shown in Fig. 241 but with further provision for supplying a suitable deflecting voltage to one set of deflecting plates. Ordinarily this deflecting voltage is applied to the plates controlling the horizontal movement of the electron beam.

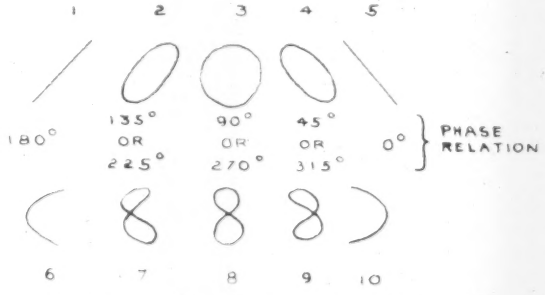


Fig. 242. Lissajou's Figures produced by different phase relationships. 1 to 5 are for two voltages with a 1-1 frequency ratio. 6 to 7 are for two voltages with a 2-to-1 frequency ratio.

Fig. 243. Saw-tooth wave produced by a sweep circuit.

It will be evident that if a direct-current voltage is applied to one set of deflecting plates, the cathode spot will move to one side of the center or the other depending upon the polarity. The distance the spot moves will depend upon the value of the applied voltage. If alternating current is applied to one set of plates, at all frequencies up to 10 cycles per second, persistence of vision of the eye gives the spot the appearance of a continuous straight line. The length of this line naturally is a measure of the peak-to-peak amplitude of the applied a-c. voltage. The line, however, gives no indication of the frequency or of the wave-form.

Suppose, however, that at the same time the alternating voltage is applied to one set of plates, the vertical plates for example, another varying voltage is applied to the horizontal plates. It is obvious that under these conditions the cathode spot will no longer trace a straight line but will form a pattern, the form of which is dependent upon the amplitude and frequency of the two voltages. This pattern will remain stationary so long as the amplitude and phase relationship of the voltages remain unchanged.

With alternating voltages applied to both sets of plates, the pattern produced by the cathode-ray spot is complicated unless certain relations exist between the frequencies and phase displacement of the two alternating voltages. Suppose, for example, that the two voltages have the same frequency and amplitude and that they are in phase. In this case the pattern is a straight line making an angle of 45° with the horizontal. As the phase of one voltage is changed the pattern becomes an ellipse which widens as the phase angle is increased and when the latter reaches 90° it becomes a circle. The patterns so formed by the application of unknown and standard voltages to the opposite pairs of deflecting plates of a cathode ray oscilloscope are called Lissajou's figures. Fig. 242 shows a number of such figures for various phase relationships and for two frequency ratios. By proper interpretation of these figures, frequency ratios up to 10 to 1 can be obtained conveniently. Thus with a 1000-cycle oscillator, calibration points between 100 and 10,000 cycles are obtainable. With a 60-cycle source of supply, calibration points up to 600 cycles are possible.

While Lissajou's figures are useful, it is usually much more desirable to supply the horizontal deflection plates with a saw-tooth voltage wave from a specially designed "sweep circuit." A wave-form of this type is shown in Fig. 243. As shown, the voltage rises linearly to a maximum value and then suddenly returns to zero or minimum value. If the time taken for the voltage to rise from zero to maximum (one timing sweep) is equal to the time required for the alternating voltage applied to the vertical deflection plates to pass through one cycle, then the pattern will portray one cycle of the vertical deflection voltage.

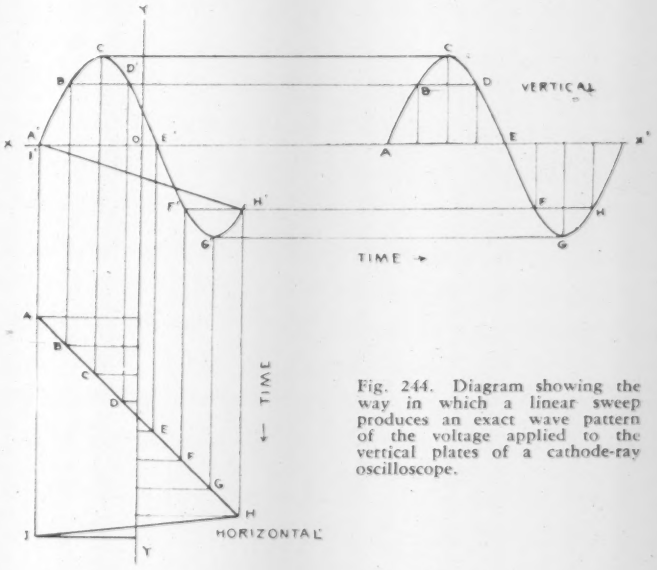


Fig. 244. Diagram showing the way in which a linear sweep produces an exact wave pattern of the voltage applied to the vertical plates of a cathode-ray oscilloscope.

The way in which a linear sweep produces a pattern of the exact wave shape of the voltage applied to the vertical plates is shown in Fig. 244. If the sweep were perfect the "fly-back" time or the time taken by the spot to return from the end H to the beginning I or A of the horizontal trace would be zero, so that the line HI would be perpendicular to the axis *Y-Y'*. While this time cannot be made zero, it can be made relatively small and can be assumed zero for most practical purposes.

A saw-tooth timing wave such as shown in Fig. 243 can be produced mechanically by means of a rotating voltage divider but it is much more desirable and effective to produce it electrically by means of a capacitor discharge

circuit such as that shown in Fig. 245A. With this circuit the capacitor C charges slowly through the resistance R to the point where the gaseous triode becomes conducting. Then the capacitor suddenly discharges through the tube and the cycle repeats itself. This action produces the voltage wave shown in Fig. 245B. The amplitude of the wave is a function of the grid voltage applied to the triode. If the resistance R is made large enough the voltage across the capacitor will rise linearly with time up to the breakdown point. To obtain a stationary pattern it is necessary

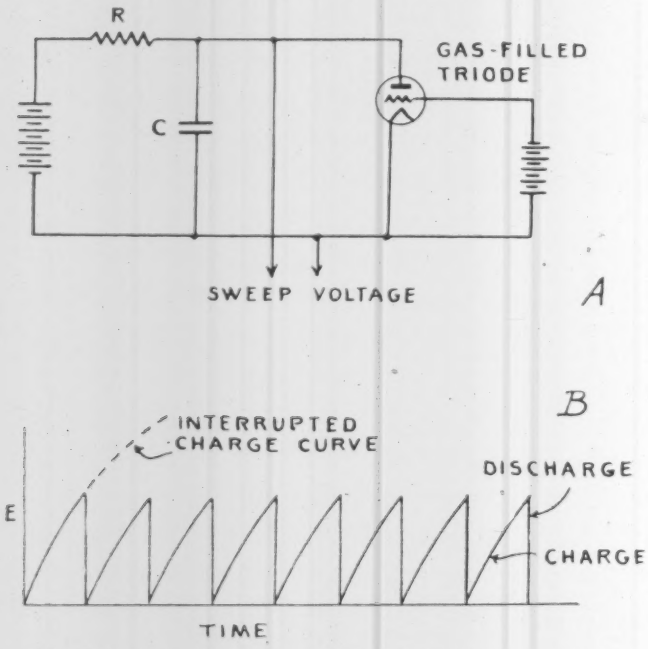


Fig. 245A. Capacitor discharge type of sweep circuit.
Fig. 245B. Voltage wave produced by circuit in Fig. 245A.

that the sweep frequency be varied and this can be done by varying C and R. In some cases, a portion of the voltage being analyzed, that is the voltage applied to the vertical deflection plates, is introduced into the grid circuit of the tube. This voltage "triggers" the sweep circuit into operaton in synchronism with the frequency of the voltage being analyzed.

The sweep circuit shown in Fig. 245A is simple and its voltage output is limited but it serves to show the principle of operation. In practice more complicated circuits are employed.

The type of wave-form analysis described in the foregoing is called cathode-ray oscillography. For a permanent record, the cathode-ray oscilloscope is used in conjunction with a camera, the latter being used to photograph the pattern on the fluorescent screen. The oscilloscope is extremely valuable and useful in analyzing the performance of electrical communication equipment where frequencies of the order of 1 to 50 megacycles are encountered and where highly complex voltage variations occur.

The cathode-ray tube also forms the heart of the modern television receiver since the picture image is formed on the screen of a cathode-ray tube.

Electron-ray Tubes

Another type of cathode-ray tube which has proved very useful is the electron-ray tube or so-called magic eye, used widely as a tuning indicator in radio receivers. It was for this purpose that the tube was developed but it has many other uses.

Figure 246 shows the basic circuit for an electron ray tube—the 6E5*. The tube contains two sets of elements, one of which is a triode amplifier and the other the cathode-ray indicator. The indicator consists of a cathode, a fluorescent anode and a control electrode which controls the portion of the fluorescent anode upon which the electron beam strikes.

With zero grid bias, the fluorescent screen or target at the top of the tube will produce a greenish glow, except for a shadow sector of approximately 100°; this pattern is shown in Fig. 247. The shadow is cast on the screen by reason of the fact that the blade-like ray-control electrode is negative with respect to the target. The ray-control electrode derives its negative bias from the RI drop across the plate resistor R_2, this drop existing as long as any triode plate current flows.

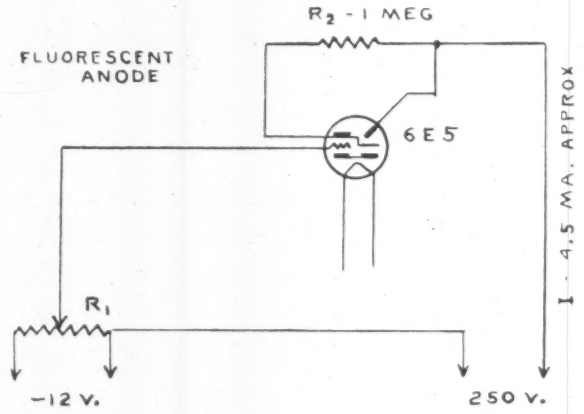


Fig. 246. Basic circuit of the electron ray tube—the 6E5.

Fig. 247. Patterns produced by electron-ray tube.

If the triode bias is now more negative by means of R_1, the triode plate current will decrease, the RI drop across R_2 will also decrease, the ray-control potential will become less negative (with respect to the target) and the shadow angle will close up. About 6 to 8 volts of negative bias on the triode grid will cut off practically all triode plate current and will reduce the shadow sector to a narrow line, as shown at the right of Fig. 247. Additional triode bias may cause the pattern to close completely, or even to "overclose"; in this case the shadow line may change into a luminous line having greater brilliance than the rest of the target.

Because the variations of the shadow sector on the target are definitely controlled by the triode bias it is apparent that the 6E5 is a negative grid voltage indicator which *does not draw power*. It can, therefore, be applied to *high-impedance* circuits with little or no loading effect. In addition, it possesses the inertialess characteristic of the electron beam (as do cathode-ray tubes) and can follow radio-frequency voltages, as well as d-c. voltages, within wide limits. It is free from the undesirable effects of mechanical inertia which characterize many types of meters.

The 6E5 is one of several types of this class of tubes available. Another tube, the 6AF6-G, contains only an indicator unit but employs two ray-control electrodes mounted on opposite sides of the cathode and connected to individual base pins. This tube requires the use of an external d-c. amplifier. With this tube, two symmetrically opposite shadow angles may be obtained by connecting the two ray-control electrodes together or two unlike patterns may be obtained by individual connection of each ray-control electrode to its respective amplifier.

As already mentioned, while these electron-ray tubes were developed primarily for use as tuning indicators on radio receivers, they can be used in a great number of

*QST, October 1935, page 25.

ferent ways. One of its most useful applications is as a vacuum-tube voltmeter.

Figure 248 shows a complete circuit of a vacuum tube voltmeter using a 6E5. The circuit was originally described by P. A. Richards and L. C. Woller.* To explain the operation of this voltmeter, suppose first that the test prods A and B are short-circuited, and that the movable arm of R_7 is at upper (plus) end of its voltage range. The plate current of the triode-connected 6C6 is practically cut off because the negative bias developed by the 2 megohm cathode resistor, R_1. Because about 14 volts of bias is required to reach the approximate cutoff of the 6C6, the

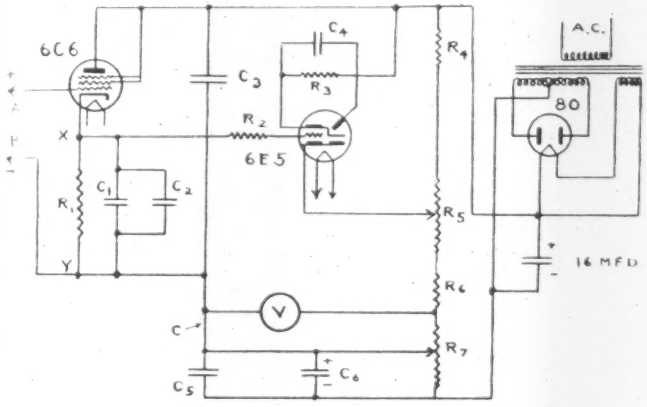


Fig. 248. Complete circuit of a vacuum-tube voltmeter using a 6E5 electron-ray tube.

cathode end of R_1 (point X) is about +14 volts with respect to the other end of R_1 (point Y). The voltage-dividing resistor R_5 (the "zero-reset" control) is next adjusted so that the voltage difference between the 6E5 cathode and point Y is about 21 volts. Thus, this 21 volts bucks the 14-volt drop across R_1 so that the net difference places a —7-volt bias on the 6E5 grid. The fluorescent pattern will now be closed to a narrow dark line. This is the correct "zero" setting for all v-t. voltmeter measurements.

With the target pattern correctly set at the zero position, any d-c. or a-c. voltage applied across prods A and B will cause the plate current of the 6C6 to increase so that the RI drop across R_1 will increase by an amount substantially proportional to the applied d-c. or *peak* a-c. voltage. The action in the case of a. c. is similar to that of a simple diode detector, where R_1 is the load resistor. Rectification occurs on each positive half-cycle, the large capacitor C_1 holding the d-c. voltage developed across R_1 at practically the peak value of the a-c. wave.

Assume now that the test prods are connected from screen to ground on a tube whose screen voltage, at the socket, is to be measured. The voltage drop across R_1 immediately increases from 14 volts to 14 + E where E is the unknown screen voltage. The bias on the grid of the 6E5 is no longer —7 volts but is some positive value (E—7), so that the pattern on the 6E5 screen "flips" entirely open. The movable arm of slide-back resistor R_7 is now adjusted toward the negative end until the shadow area of the 6E5 again closes to its "zero" or narrow-line position. When this occurs, the d-c. voltmeter V will read the screen voltage being measured. In simpler words, the voltage to be measured robs the 6E5 of its original bias (opening the pattern) and the dividing visitor R_7 adds just enough additional negative bias to cancel the unknown voltage, thus restoring the pattern to its original position. Voltmeter V should be preferably one of the 1000 ohms-per-volt variety having three ranges such as 10, 250 and 750 volts.

An instrument such as the one described can be used for a variety of measurements in radio work. Screen and plate voltages of electron tubes can be checked with great precision. I-f. or r-f. stages can be checked when receivers are in operation by measurement of the r-f. voltage across the transformer secondary. It can be used as an output meter or the actual gain of an amplifier can be measured. The peak plate current of a mercury-vapor rectifier can be measured as a check on rectifier operation, or the ripple voltage of a high-voltage power supply can be determined with this voltmeter. In short, it is a very valuable instrument and simple and inexpensive to make. Considerable space has been devoted to its description here, because it belongs to a category of electron-tube applications that makes full use of the extreme sensitivity and versatility of the electron tube.

An Electron-tube Translating Device

An interesting application of the cathode-ray principle is that inherent in a so-called "translating device" developed by Herbert Ziebolz of Chicago and covered in U. S. Patent No. 2,314,302 issued March 16, 1943. This device is intended for use in relaying, amplifying or converting electrical or magnetic signals into other values of voltage or current for use in control or measurement. One form of the device is shown in Fig. 249. It consists of a cathode-ray tube but in-

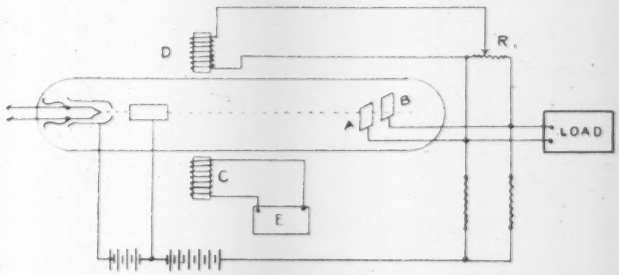


Fig. 249. Showing the principle of the Ziebolz electron tube.

stead of having the usual fluorescent screen at the end of the tube there are two plate type anodes, A and B, mounted side by side as shown.

Initially the electron beam can be assumed to be centered between the two anodes. If, however, it is deflected by the magnetic field of Coil C, the cathode ray will impinge on either of the two anodes, depending upon which way it moves. This will result in a difference of the number of electrons reaching the anodes and this manifests itself as a potential between the two plates. As a consequence of this difference in potential, a current flows to the load which varies in accordance with the variation of the signal supplied from source E. A portion of this load current also passes through coil D, the purpose of which is to counteract the influence of coil C. As a result of the action of coil D, the cathode ray is brought back to its original position. The current through coil D may be regulated by means of voltage-dividing resistor R.

The device is essentially one which employs a cathode ray as a null method of control or measurement. There should be many applications for a device of this kind. The deflection of the cathode ray can be accomplished electrostatically instead of magnetically or it can be done through mechanical systems using moving magnets.

The Mass Spectrograph

An instrument that has become of increasing importance in atomic research in recent years is the mass spectrograph. The mass spectrograph makes use of the fact that when particles having the same electric charge but differing slightly in mass are accelerated through the same potential in a strong magnetic or electric field, the particles will be deflected in accordance with their respective masses. The lighter particles will suffer greater deflection than the heavier particles. Mass spectrographs have been widely used in the investigation of isotopes, i. e., atoms of the same element that possess the same charge but differ slightly in mass. Though these instruments vary widely in detail and complexity, the principle in all of them is basically the same.

Radio Retailing, December 1936.

XXXIII. OSCILLATOR APPLICATIONS IN THE FIELD OF INSTRUMENTATION.

The ability of the electron tube to generate sustained electrical oscillations between wide limits of frequency, as has been explained in earlier articles, is perhaps its most outstanding quality. This characteristic is, of course, a consequence of the tube's ability to amplify—it depends on the tube being able to return a portion of its output back to the input. The principal application of the oscillating properties of electron tubes is in radio transmitters where they generate the high-frequency currents delivered to the antenna and in radio receivers to generate the local frequencies needed in frequency conversion.

Electron-tube oscillators also have many applications in the field of industrial measurement and control. They form the very heart of high-frequency induction heating equipments used in the heat treatment of metal parts; similarly, they supply the high-frequency dielectric current used in the bonding of plywood and in the drying of other products.

In the field of measurement they are used for the measurement of thickness, as ultramicrometers, in temperature measuring and recording devices, as frequency standards and as frequency meters. The latter perhaps is their most fundamental use in the field of electrical measurement. Fundamentally, any process of measurement consists in comparing an unknown magnitude with a standard. Since an electron-tube oscillator itself constitutes a frequency standard, it also becomes a frequency meter. Frequency is measured by counting the number of cycles or oscillations per second. Since this cannot be done directly at very low frequencies, other methods are necessary in electrical measurement. A simple and obvious method is to compare the unknown frequency with a tuning fork whose period of vibration is known or can be calculated. This is the principle used in the vibrating-reed type of frequency meter. Another method is by noting the response of a selective or resonant circuit such as a tuned circuit consisting of a capacitance and an inductance. The most precise method of measuring high frequencies is that of comparing the unknown with a known frequency, either matching it directly with a variable calibrated source as in the heterodyne frequency meter or by measuring the difference between the unknown and a fixed frequency standard (oscillator) of which the frequency is known by interpolation.

The simplest type of frequency meter is the absorption type consisting merely of a coil and a variable capacitor in parallel with some sort of current-indicating device in the

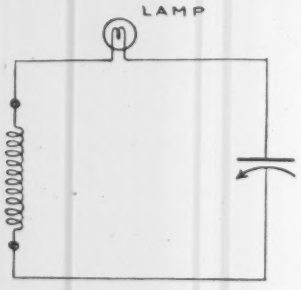


Fig. 250. Simple absorption type frequency meter.

circuit (Fig. 250). The latter can be a small incandescent lamp or a milliammeter. A circuit of this kind constitutes a tuned circuit and when it is loosely coupled to another oscillating circuit it will extract a small amount of energy from the oscillating when it is tuned to the same frequency as the oscillating circuit. Maximum current will flow when the circuit is in electrical resonance with that of the circuit being measured and this resonance is indicated by the brightness of the indicating lamp or the maximum reading of the milliammeter, whichever device is used. As a matter of interest, the indicating device can be dispensed with entirely if the circuit from which the energy is extracted has an ammeter or current-indicating device in it. As the frequency meter is tuned to resonance, the current in the supply circuit will increase and this will be shown by the indicator in that circuit. The absorption type of frequency meter, obviously, is not an electronic device since in its simple form it does not require the use of electron tubes. Some of the modern forms use a vacuum-tube voltmeter to indicate resonance and, of course, such designs are classified as electronic instruments. Absorption frequency meters are not used much at the present time except for rough checking of r-f. oscillators, but they form an important link in the history of the development of modern frequency meters. These absorption type frequency meters are mostly called wavemeters since the early models were calibrated in terms of wave-length rather than frequency.

In modern precise frequency measurement the absorption type frequency meter has been almost entirely superseded by the heterodyne frequency meter. This is simply a small completely-shielded electron-tube oscillator with a precise frequency calibration covering a certain frequency range. Such an oscillator must be very carefully designed and constructed so that once it is calibrated it will retain its calibration over a long period of time. The frequency of oscillation at any particular setting must be practically the same under any and all conditions.

One of the most stable oscillator circuits and, therefore, the most suitable for use in a frequency meter, is the elec-

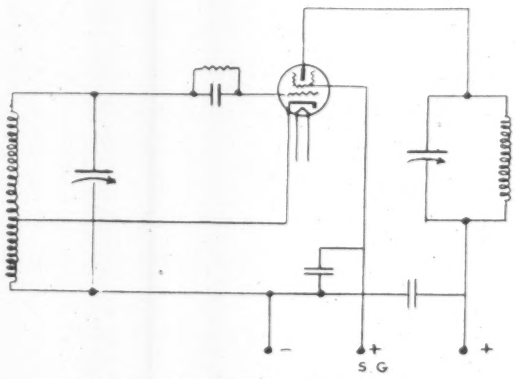


Fig. 251. An electron-coupled oscillator.

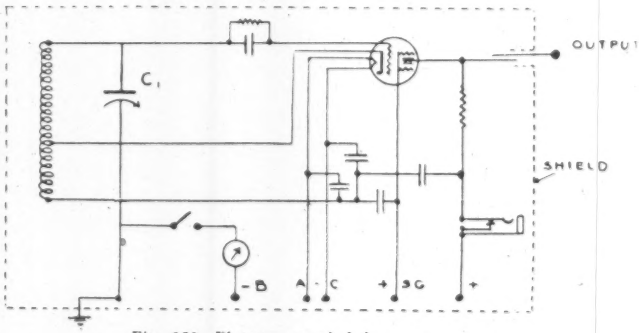
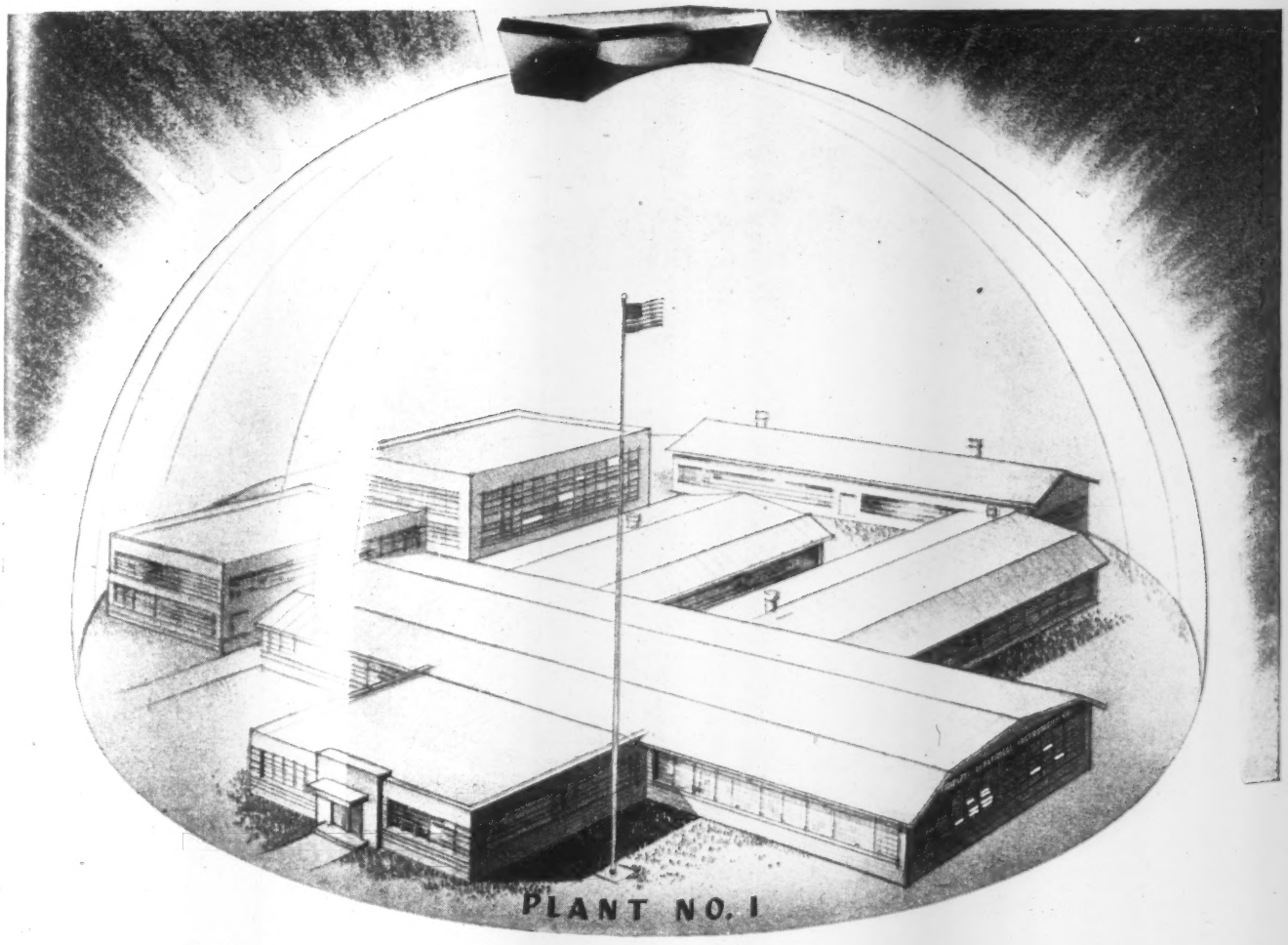


Fig. 252. Electron-coupled frequency meter.

tron-coupled circuit. With electron coupling the oscillation frequency is practically independent of moderate variations in supply voltages and furthermore because of the nature of the circuit it is possible to take output from the plate with but negligible effect on the frequency of the oscillator.

In the discussions of the various types of oscillator circuits in earlier articles it may be recalled that when a portion of the output of an amplifier was fed back into the input, the circuit would produce sustained oscillations. In some instances such coupling was carried out inductively, in others capacitively. With electron coupling, use is made of the screen grid (tetrode) tube. As shown in Fig. 251, the control grid, cathode and screen grid, the latter being used as a plate, are combined in a conventional triode oscillating circuit with the screen grid at ground potential for r-f. voltage. The output of the oscillator is taken from the regular plate through a separate tank (tuned) circuit. With a well-screened tube, the coupling between the "oscillator"

Continued on page 107



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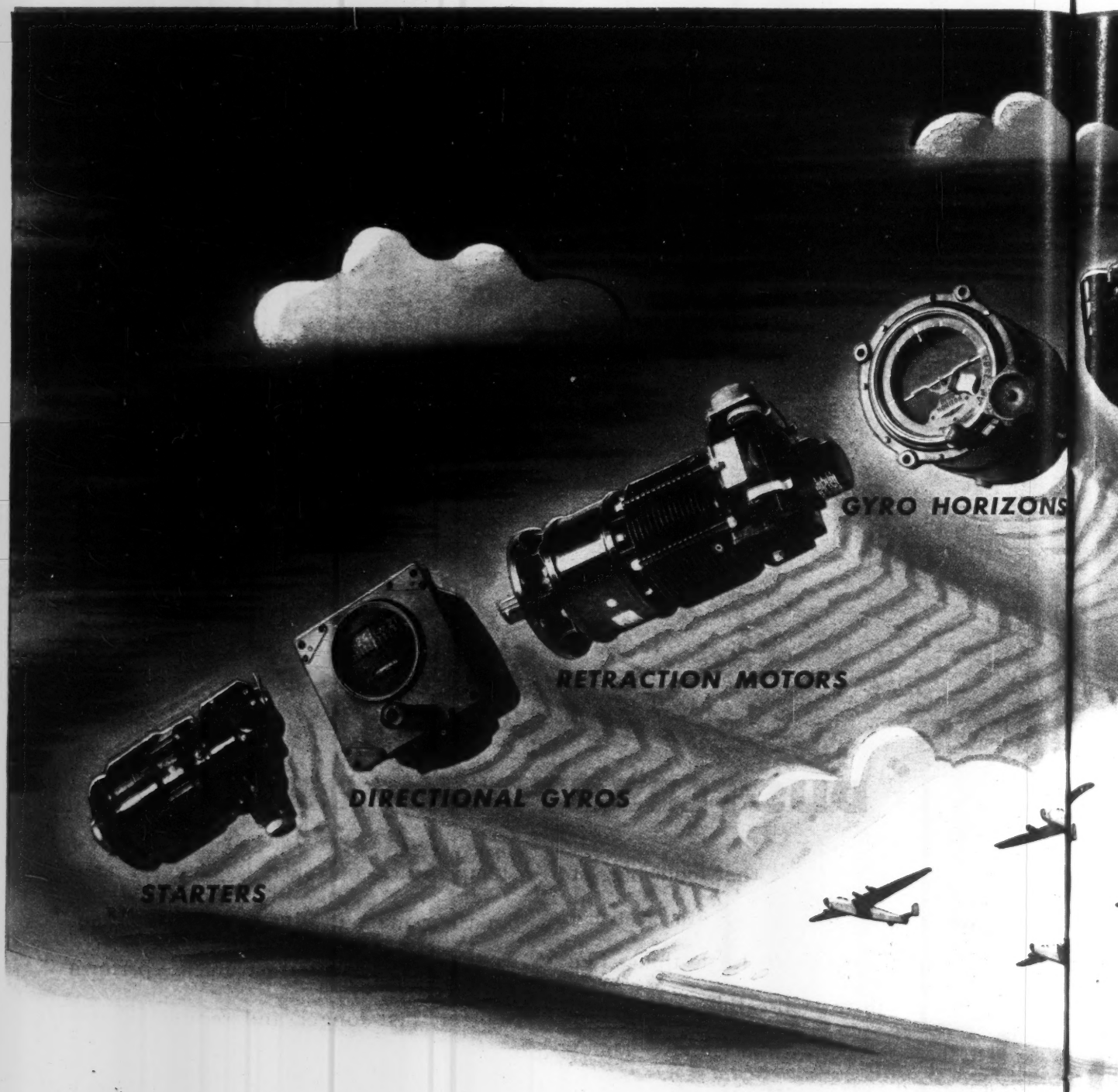

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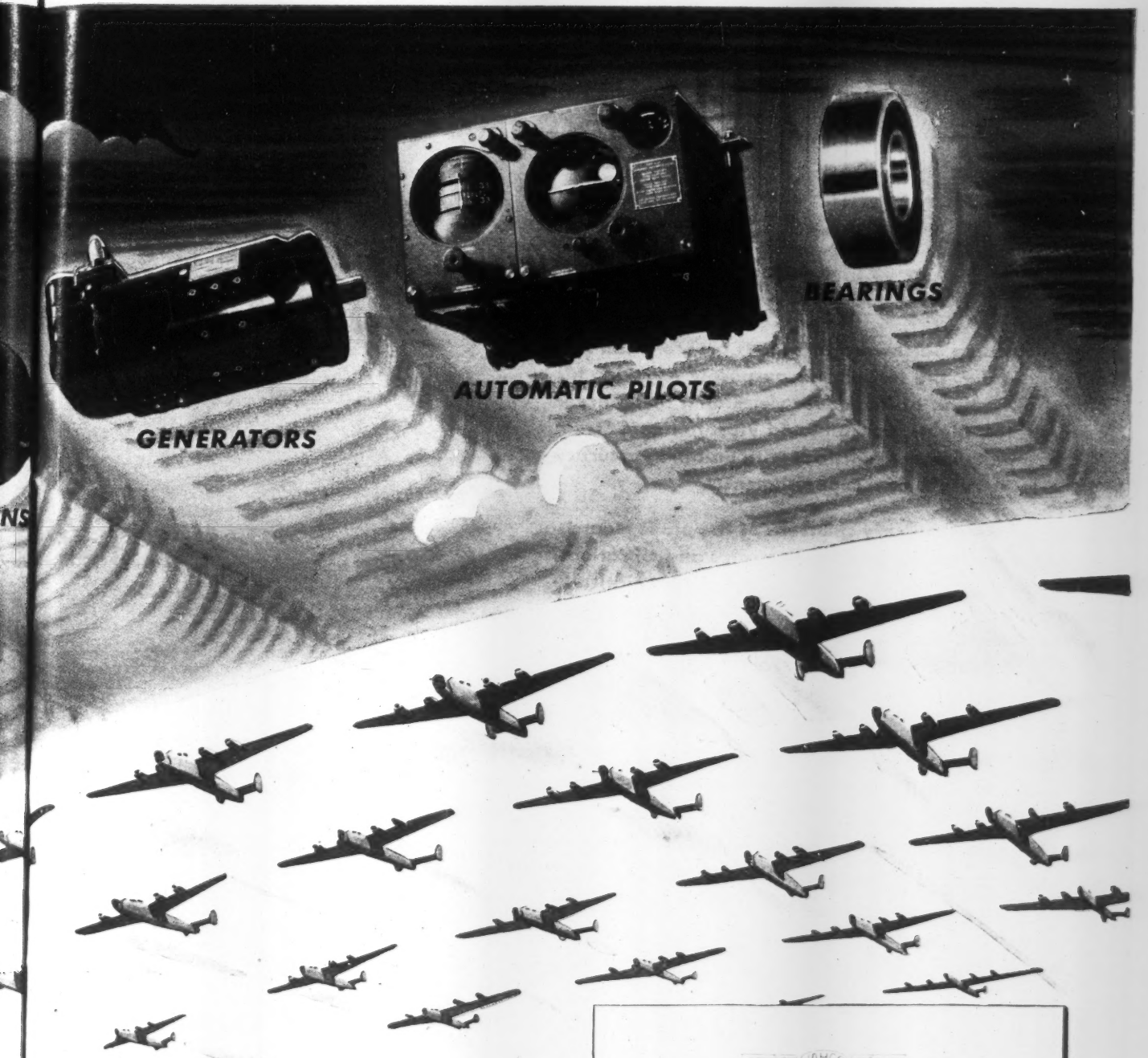

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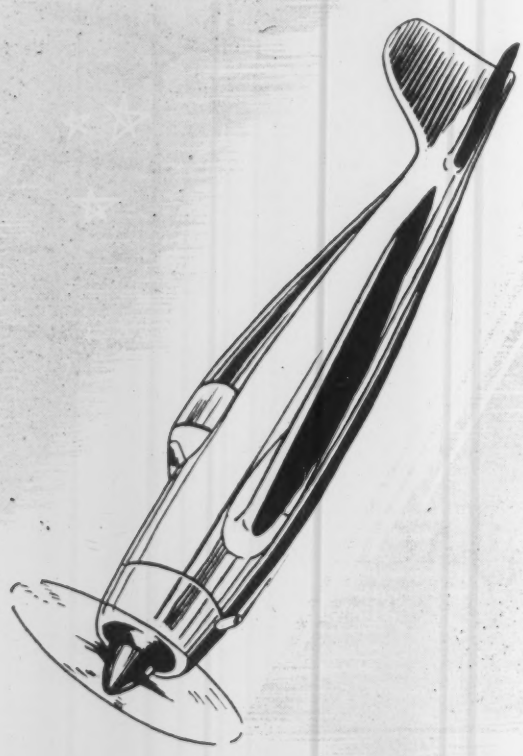

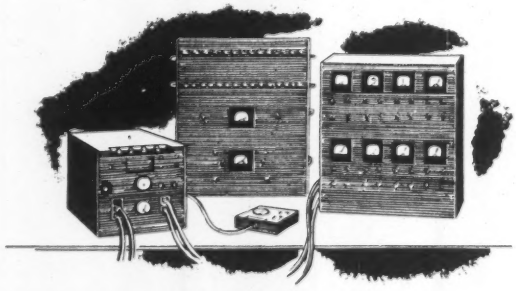

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Vol. IV, No. 2 M, F. Béhar, Editor February 1945

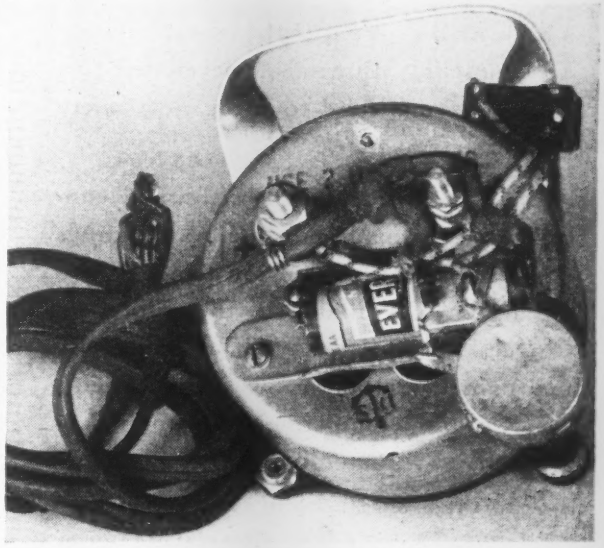
Checking Cylinder-head Temperature Indicators

By M. J. WIGGINS, USN Air Station, Vero Beach, Fla.

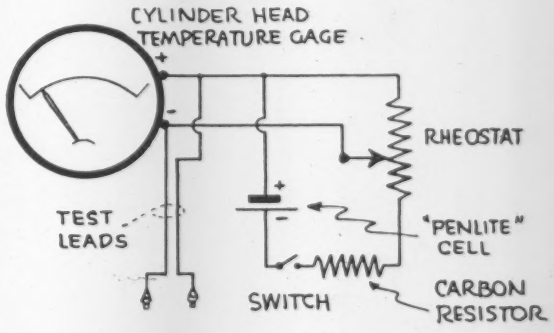
CYLINDER-HEAD temperature tells the "health" of modern high-power aircraft engines. A higher-than-normal reading is often a sign of serious trouble such as detonation. Low readings may indicate faulty plugs, too-rich mixture, etc. However, before the mechanic tears into the engine, he wants to be certain that his cylinder-head temperature indicator is reading correctly! The tester shown in the photographs was built for this purpose. It is easily-built, rugged, small and easy to carry about. All parts are readily available at most activities.

In use, one lead is disconnected from the suspected indicator and the two test clips attached to the terminals, observing polarity. The indicator and the tester should be at approximately the same temperature and both zero-adjustments set the same. The toggle switch on the handle of the tester is turned ON and the small knob is turned to vary the readings. At every 50° mark the indicator should be checked for agreement with the tester within the required tolerances.

The tester is constructed from a cylinder-head temperature gage which has been accurately calibrated at an overhaul shop. The mounting nut is removed from the lower



left-hand corner and the hole enlarged to take a 3/16" shaft. The rheostat (preferably a wire-wound unit of about 5000 ohms) is mounted on the back of the gage with a bracket. This rheostat has a 3/16" diameter extension soldered to its shaft, projecting through the enlarged lug-hole. Various carbon resistors should be tried in the circuit (shown in the diagram) until full-scale readings are



obtained with two indicators in parallel when the rheostat is turned fully ON. This carbon resistor and the "penlite" cell may be held in place by their connecting wires. The test leads are so anchored that there will be no strain on the connections. The clips should be marked as to polarity. An aluminum cover, insulated on the inside with paper tape, should be made to cover the rear assembly. (This cover has been removed in the rear-view photograph) The handle is made from an aluminum strip and serves to mount the on-off switch.

Note: The tester must be used only on the type of indicator from which it was made. A copper-constantan tester will not work on an iron-constantan indicator.

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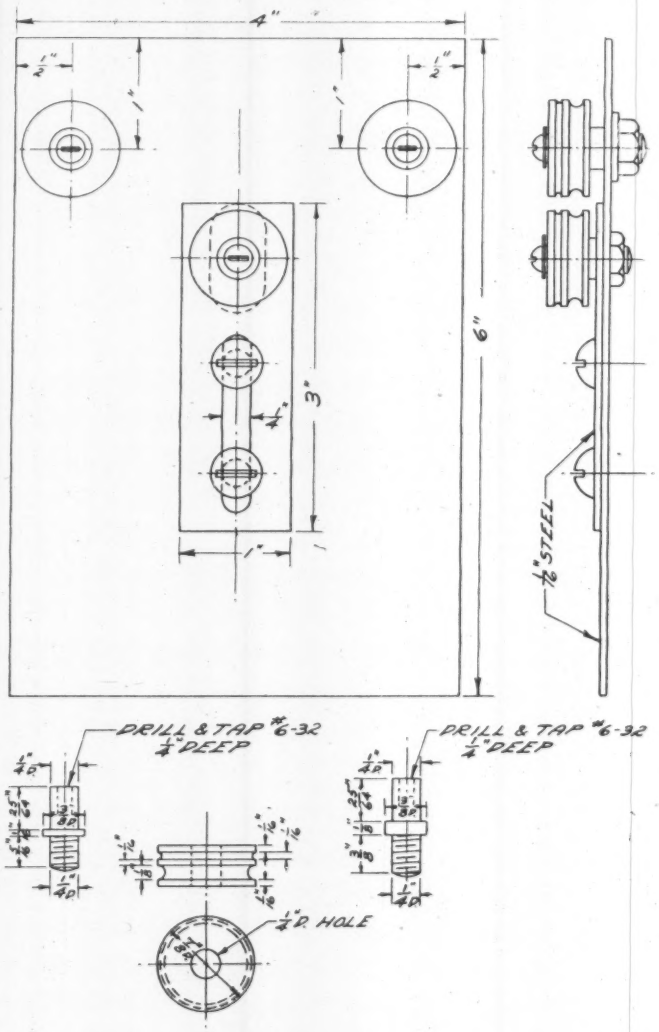
Thermocouple Wire Straightener

By W. E. COLBATH, 120 Myrtle Ave., Portsmouth, N. H.

THERMOELEMENT wire usually comes in coils and therefore has to be straightened before it can be made up into the finished couples. Too much bending in this process may cause inhomogeneity in the wire, creating "hot spots" which may affect the accuracy of the couple.

The small accessory described in this article was designed for the purpose of straightening a coiled wire with a minimum of bending. Its design and the dimensions of its components are given in the drawings. It was assembled of odd pieces of material which can easily be found in the average shop. The wheels were made of plastic, which is recommended to prevent scratching the wire. These wheels and the studs were turned on a lathe, the whole job taking but little time. The base was designed to be clamped into a vise for convenience of operation.



It will be found that different wires such as Chromel, Alumel, iron, etc., will require a different setting of the adjustable center wheel. These settings may be ascertained after a few trials and suitable markings made on the base plate.

Mounting Hairsprings

By Pfc. BILL ENGELHARD, MCAS A&R, Cherry Point, N. C.

STUDENTS recently returned from one of the country's well-known instrument schools report that the problem of attaching hairsprings to moving coils had been left

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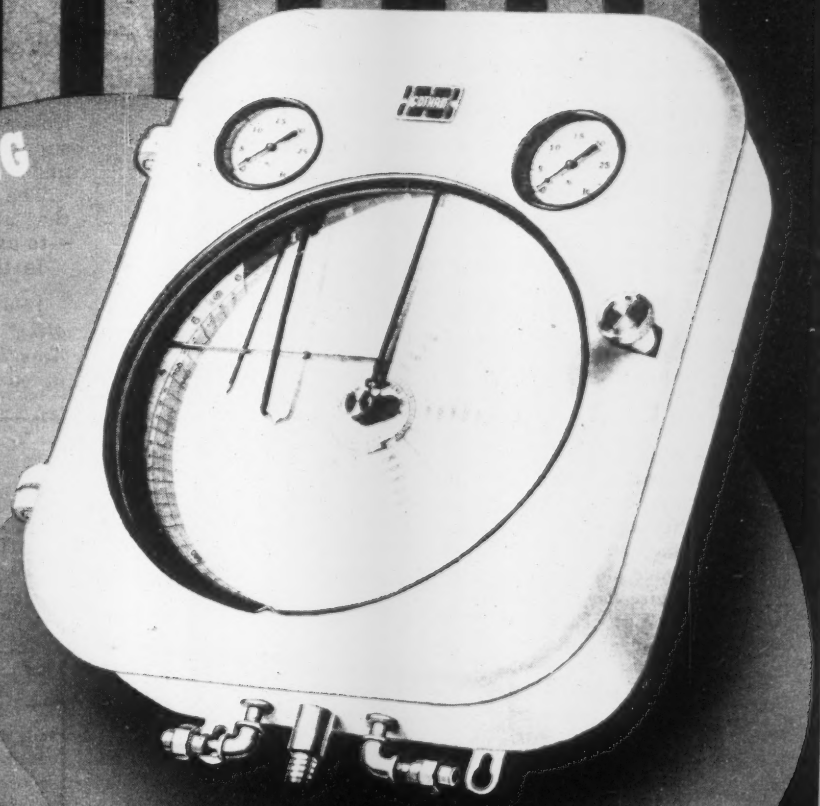
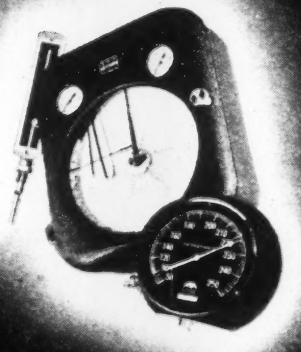


SEND FOR ILLUSTRATED CATALOG K 45



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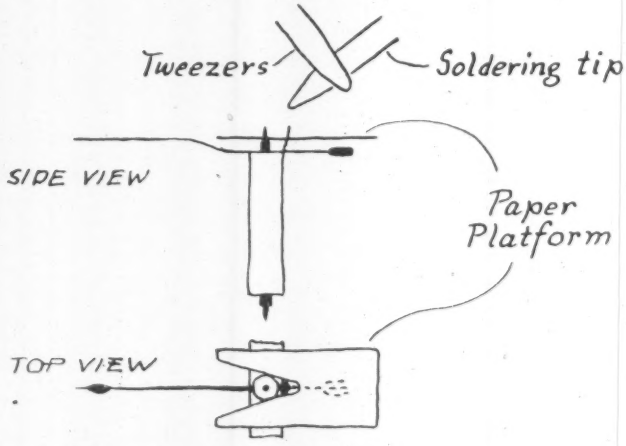
entirely up to them. "There are numberless techniques for mounting hairsprings. Each of you will have to develop your own," was the limit of instruction according to one graduate.

Where it is not feasible to construct special fixtures, we have found both at home and the shop here that no method works better than "building a paper platform," as sketched.



After placing the element assembly on the familiar "duck," the operator slides the platform around the inner hairspring support. A slight tug from the forked ends locks it fast. It is then a simple matter to slide the inner turn of the spring against the support. As both hands are free, tweezers may be used to steady the point of the soldering iron when bringing it in contact with top of the hairspring support. After soldering, the paper is "slipped out from under."

The only precaution I have found necessary is insistence that all platforms be cut by sharp razor blades or scissors —to avoid leaving minute bits of fuzz.

Is this "old stuff" to you old-timers?

[*No, but a different type of paper platform, for untangling hairsprings, was described by Otto Thress of the American School of Aircraft Instruments (Glendale, Calif.) in our December 1942 issue, page 528.—Editor*]

Cash for Shop Kinks

on instrument repair, testing, installing, etc.

This is to remind our readers that *Instruments* pays $5 (or more) for each shop kink or other time-saving and accuracy-promoting idea accepted for publication. The following rules must be observed:

1. Type double-spaced on one side of paper. Author's name and address at top of first page (envelopes get lost!)
2. Diagrams must be in black ink (no blueprints).
3. Only professional-grade photos will be accepted (preferably 5 x 7 or 8 x 10 glossies).
4. Each contribution to describe ONE method or device. An author may send as many as he likes.

Share Your "Know-how"

Postwar Air Passengers Assured of Correct Cabin Temperature

MINNEAPOLIS. — Postwar air travelers will depend upon tiny coils of wire to keep warm while roaring through the sub-stratosphere, according to an announcement by the Minneapolis-Honeywell Regulator Co. The coils, like fingers reaching ahead of the plane, will anticipate temperature requirements and command the heaters to deliver more or less

He guessed . . . *and lost!*

Higher speeds and greater production have made it expensive to indulge in even the most skillful guesswork. A miss today is also as good as a mile when counting tons per hour or revolutions per minute.

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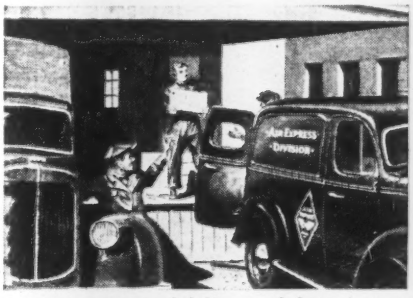
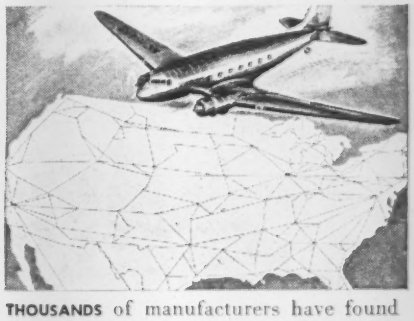


SPECIAL PICK-UP and delivery of shipments at both ends, with speed of flight in between! The great economy of Air Express must be figured in terms of *time*. When time means money, Air Express saves both.



THOUSANDS of manufacturers have found that Air Express usually saves many times over its cost. (Any item anywhere in the nation is yours in a matter of hours, so long as the shipment fits in a plane.)

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25 lbs., for instance, travels more than 500 miles for $4.38, more than 1,000 miles for $8.75, more than 2,000 miles for $17.50, at a speed of three miles a minute—with cost including special pick-up and delivery in all U. S. cities and principal towns. (Often same-day delivery between airport towns and cities.) Direct service to scores of foreign countries. Rapid air-rail service to 23,000 off-airline points in the United States.

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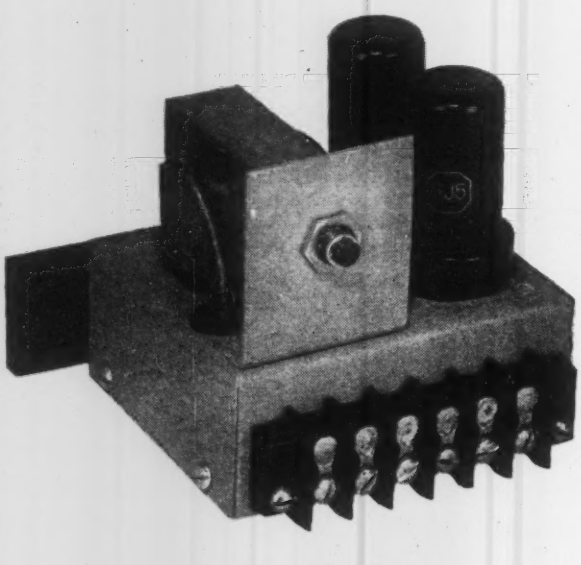

Model 5010 has been serving wartime industry for many months. Various sequences and intervals are available for industrial machine control.

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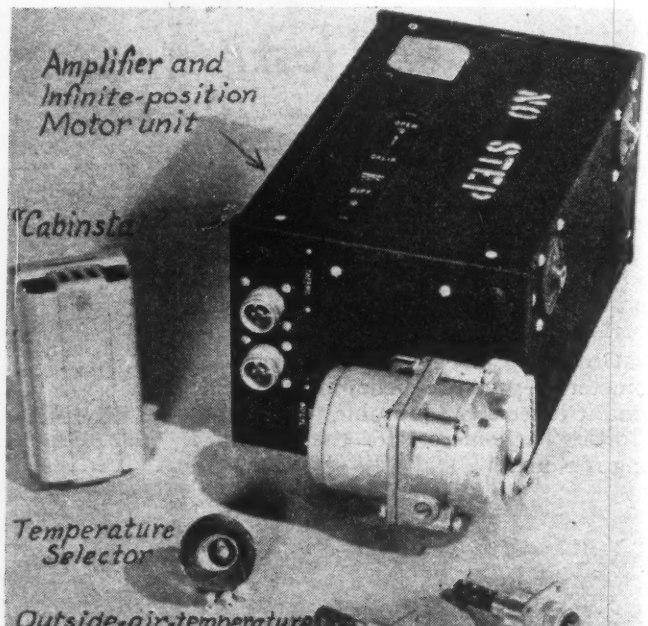
heat even before passengers realize what's going on in the outside air, it was said.

Completely automatic, the system goes under the length name of the "Electronic Cabin Temperature Control System" and has been in test service on several airlines and combat use on Army transport ships for some time, R. H. Whempner, Chief Field Engineer for the company's aeronautical division, said.

"Controlling temperatures in a house is one thing," he said, "but controlling temperatures in an airplane is quite another. The temperature outside a home fluctuates only gradually. But an airplane moves from one temperature condition to another in a matter of seconds, and sometimes these changes are 50°F. or more."

The principal part of the new control system is a package unit weighing slightly under 8 lbs., he stated. The system as



Principal components of postwar airplane cabin temperature control system. Not shown in this photograph are safety switches and valves which automatically cut off the flow of gasoline to the heaters if the fuel line breaks; and an "Air Ram Switch" which automatically guards against operation of the heaters until sufficient forward speed is obtained to "drive enough air over the heaters for adequate combustion," according to the announcement.

a whole is designed to hold automatically any cabin temperature selected by the pilot. To passengers this means perfect comfort conditions under all kinds of flying weather, and to pilots and stewards it means an end to passenger complaints and the nuisance of constantly making adjustments of manual controls.

Connected to the master control switch in the cockpit, the new control system is automatically turned on when the pilot starts the engines, Whempner said. However, unless heat is required immediately, the heating system remains inoperative until the outside temperature falls to a point requiring the addition of heat for passenger comfort. At this point, without any attention from the pilot, the heating system starts delivering heat to the cabin in the exact amounts needed to maintain the preselected temperature—usually 70°F.

The Honeywell engineer explained that the system anticipates changes in demand because it includes an outside-air-temperature compensator. This, he said, is a small coil of wire installed in the duct bringing outside air into the plane's heaters. Temperature fluctuations change the electrical resistance of the wire and although this change is only slight, it can easily be measured by a bridge-circuit

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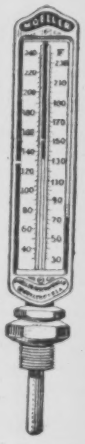

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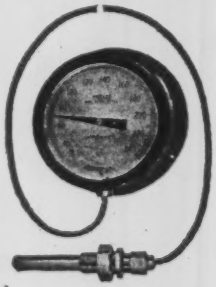

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instrument. Serving as the brains of the system, the measuring instrument learns from the coil that the outside air is colder or warmer, as the case may be, and it sends electrical commands to a motor which opens or closes a mixing damper and thus proportions the amounts of outside air with heated air from the plane's heaters.

The system also includes a "Cabinstat," Whempner pointed out, which is another coil of wire mounted in the cabin and serving about the same function as a thermostat in a house. This, too, interprets temperatures and sends messages to the instrument brains which, getting signals from both coils, position the mixing damper to maintain the selected inside temperature. The latter, he said, is determined by a small dial mounted in the cockpit.

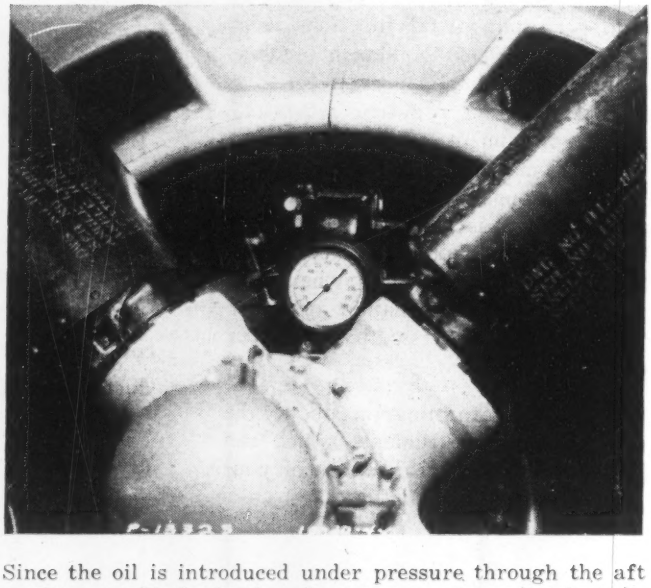
If a plane takes off while ground temperature is 70°F., no cabin heat is required, he continued, but as it climbs to high altitudes, outside temperatures take a nose dive. The little outside compensator notices this drop immediately and tells the controller which, in turn, commands delivery of heat to the cabin. The passengers are not conscious of the outside change, he said, because of the reservoir of heat in the cabin. *Before this heat is lost to the outside,* making the passengers uncomfortable, heat is coming into the cabin in the exact proportion needed to maintain a constant and comfortable temperature.

The reverse is true when the plane moves into warmer temperatures, he continued, because while the inside "Cabinstat" calls for heat, the outside coil knows that less heat will be required and so less heat is delivered.

All of this, Whempner claims, is not complicated. But the airline traveler doesn't particularly care if it is or not. All he needs to know is that he can ride in complete comfort while flying from summer through winter temperatures.

Pressure Gage Speeds Pre-oiling

PRE-OILING of engines on the B-26 Marauder prior to their initial start has been greatly improved at The Glenn L. Martin Co., Baltimore, Md., by the installation of a pressure gage on the governor pad in the nose section.



Since the oil is introduced under pressure through the aft section, any blocks in the oil system are immediately indicated on the gage. Correspondingly a correct reading on the gage insures that all parts are properly lubricated.

Installation and removal of the gages takes only a few minutes—which is not lost time but time well invested in protection against failure and damage to valuable equipment.

Credit for developing this engine-saving practice goes to the many craftsmen of the ground test line at the Martin Airport.

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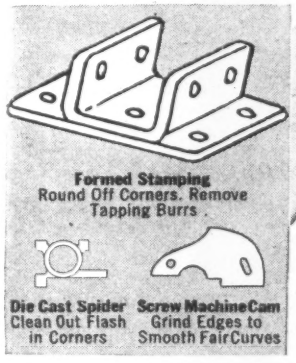

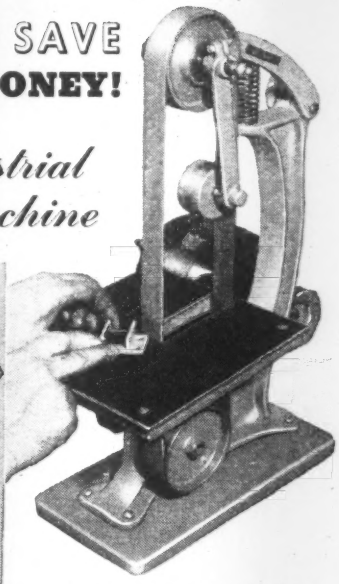

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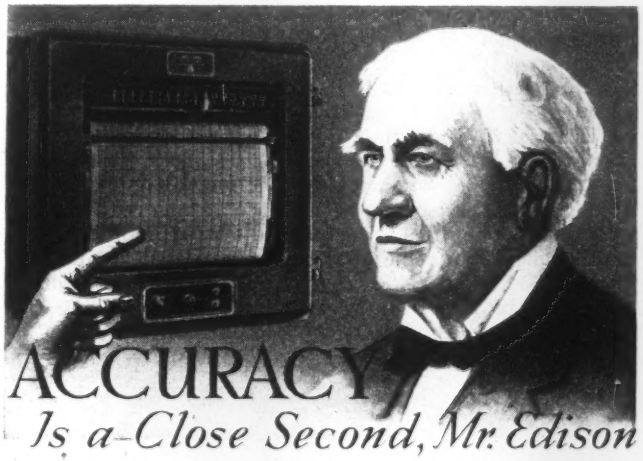

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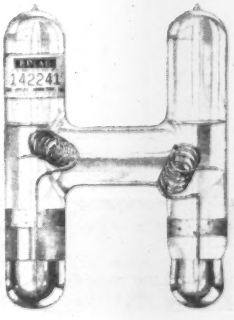

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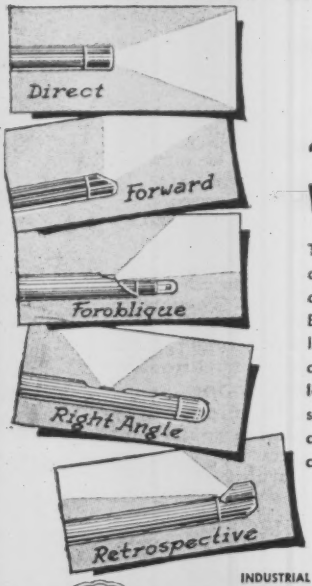

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Electric Gaging Methods

(Continued from Page 84)

in Fig. 112. Two separate optical systems are used, each comprising a front lens, an optical grating, a rear lens, and a photoelectric cell. The front lens forms an image of the field being scanned on the optical grating; the rear lens takes the light passing through the clear spaces of the

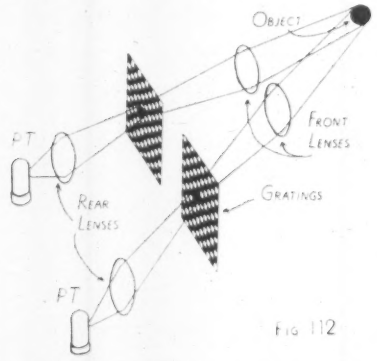


FIG. 112

grating and focusses it upon the phototubes *PT*. The two gratings are the inverse of each other; where one is transparent the other is opaque. The two optical systems and the electrical circuits are so adjusted that exactly the same area is covered by each of the systems, and the outputs of the two phototubes are equal. No electrical output appears when this condition obtains. But if an object enters the field, this balance is disturbed, and an electrical output is produced.

When checker-board gratings, such as those illustrated, are employed, the device is sensitive to objects moving in any direction across the field; if the gratings consist of parallel bars, it becomes insensitive to objects moving in a direction parallel to the bars of the gratings. The electrical circuit can be made to respond to any *intrusion*, or simply to any *movement*. The system has been used in a number of applications, ranging from anti-intrusion systems to material inspection.

There is available a wide variety of electric circuits in which photoelectric devices can be placed;[222] no detailed description can be given in this section. In addition to the most elementary connection, to measure *amount* of light, it is possible to measure sums and differences, ratios and logarithms, through simple electric circuits only. If cams, optical wedges, and other devices are introduced into the system, the possibilities are expanded almost infinitely. The circuit employed in some of the light-ratio devices just described[247,254] is a bridge circuit of the Wheatstone form; it is shown in Fig. 113. Another method of securing the ratio action is to connect two phototubes back-to-back, as

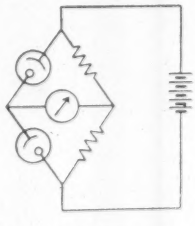


FIG. 113

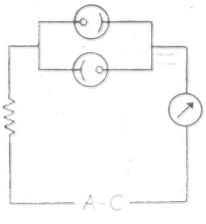
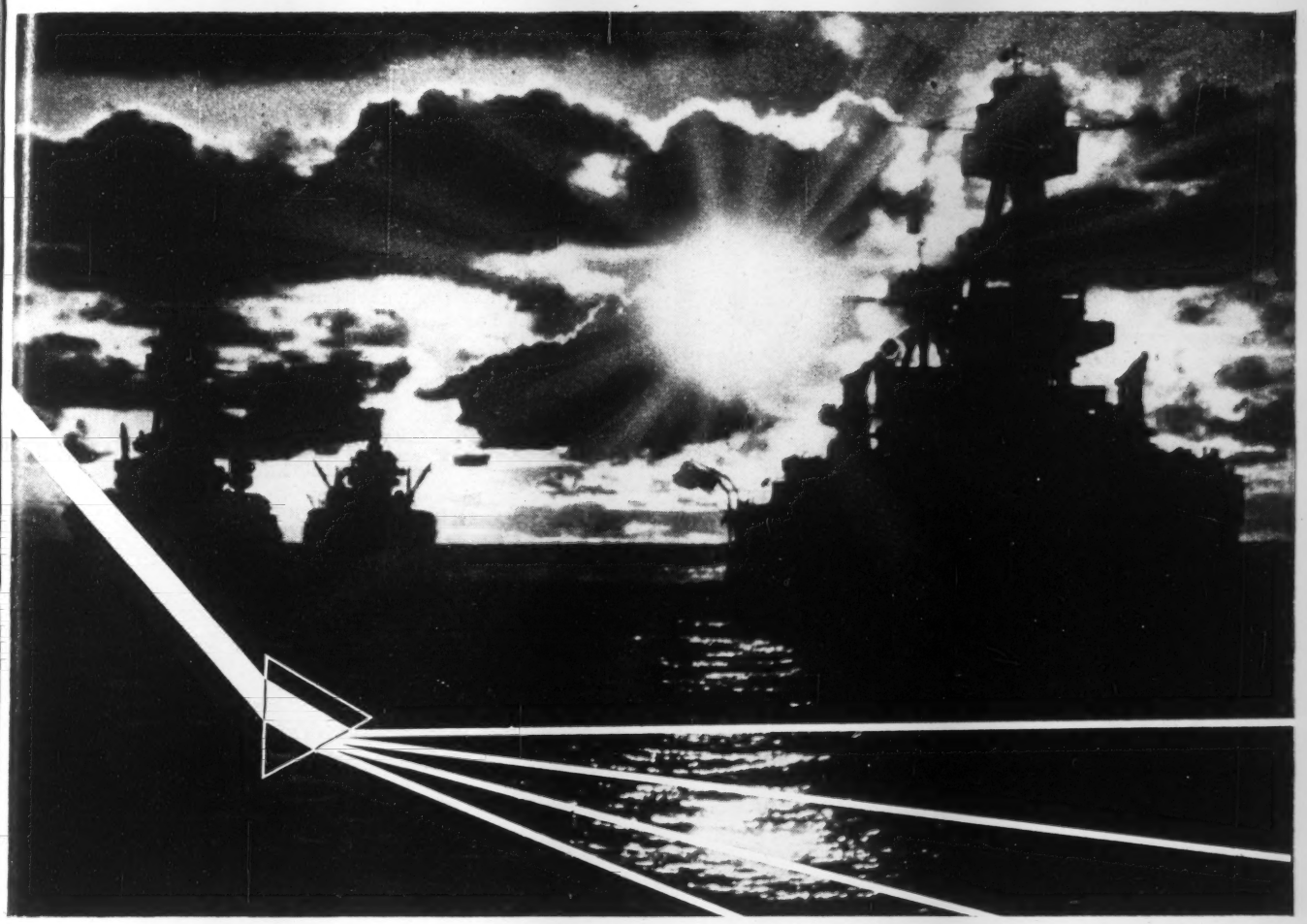


FIG. 114

shown in Fig. 114. Since an emissive-type phototube is a rectifying device, and conducts current in proportion to the illumination, if a-c. excitation is applied current will flow, its direction and magnitude indicating the ratio of the light striking the two phototubes. Although the figure shows a current-measuring instrument the current flowing is so small that amplifying systems are almost always used. Other connections are used for particular purposes, each suited

(254) Alan S. Fitzgerald. The Petoscope: A New Principle in Photoelectric Applications. *Journal of the Franklin Institute*, Vol. 222, 1936, pages 289-325.



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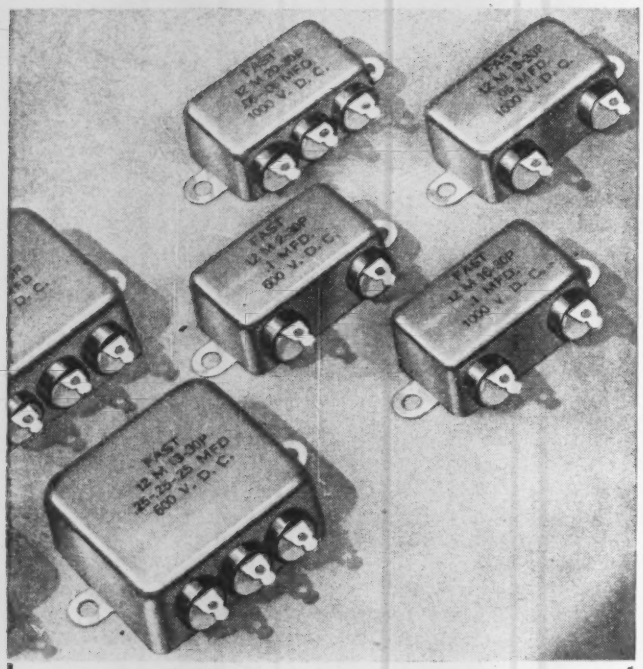

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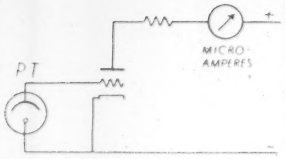

Fig. 115

to its use.[255] One extremely simple circuit converts light intensities into logarithms directly[256] through the use of a tube which (in this circuit) suffers a plate current change in proportion to the logarithm of the resistance in the grid circuit. The basic circuit is drawn in Fig. 115.

To be continued

(255) F. H. Shepard, Jr. Some Unconventional Vacuum Tube Applications. *RCA Review*, Vol. 2, October 1937, pages 149-160.

(256) John Russell. A Photoelectric Cell Circuit with a Logarithmic Response. *Review of Scientific Instruments*, Vol. 8, 1937, pages 495-496.

Electron Tube Principles

(Continued from Page 88)

and the "output" portions of the circuit is almost entirely through the electron stream, so that capacitance effects are absent.

This principle of operation is used in the electron-coupled frequency meter shown in Fig. 252. An instrument such as this is usually designed so that the variable capacitor C_1 will cover completely the lowest frequency range for which the instrument is intended to be used. Suppose this is from 1715 to 2000 kc. For higher frequencies, the harmonics of the oscillator are used. Thus the second harmonic will cover the 3500-to-4000-kc. range, the fourth the 7000-to-8000-kc. range, and so on.

In use, the signal from the oscillator (or a harmonic) just described is fed into a receiver or simple detector together with the signal to be measured and the two frequencies are heterodyned, that is the two frequencies are made to beat against each other. As the variable capacitor C_1 is gradually varied, the frequency of the oscillator will gradually approach that of the signal being measured—the pitch of the beat note will gradually decrease. At zero beat with the signal, the frequency of the oscillator or the harmonic multiple will be the same as the unknown frequency, and the latter therefore can be read directly from the frequency meter dial.

Beat-frequency Oscillators

An instrument that has come into extensive use in recent years in laboratory measurement work is the beat-frequency oscillator. This type of oscillator is used to provide a source of audio frequencies over a considerable range. In this type of oscillator, shown schematically in Fig. 253, the outputs of

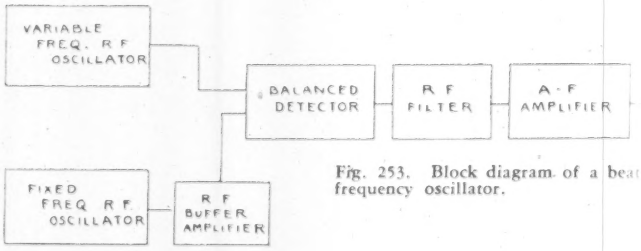

Fig. 253. Block diagram of a beat-frequency oscillator.

two oscillators of slightly different frequencies are combined to produce the desired audio frequencies. One of the r-f. oscillators operates on a fixed frequency while the frequency of the other is varied by means of a variable capacitor. Suppose the fixed-frequency oscillator operates at 100,000 cycles. Then, if the variable-frequency oscillator happens to be set at 90,000 cycles the result of mixing the two frequencies would provide two additional frequencies, one the sum of the two, namely, 190,000 cycles, and the other, the differ-

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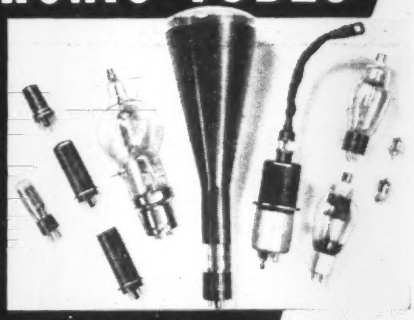

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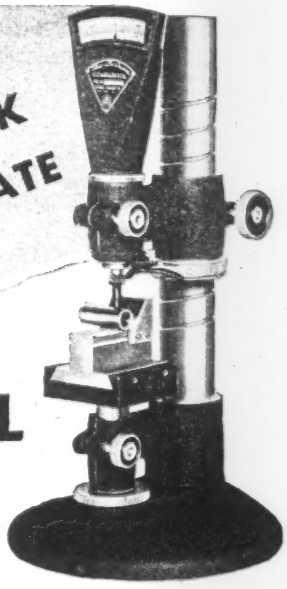

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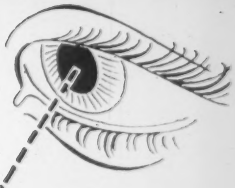

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ence of the two, or 10,000 cycles. If the latter is the desired audio frequency, this is amplified while the other three frequencies, that is, the two original radio frequencies and their sum, are filtered out by means of filter circuits.

The principal advantage of this type of oscillator is that the whole range of audio frequencies from 0 to 15,000 or 20,000 cycles can be covered by means of a single dial. In one type this frequency range can be doubled (the range extended to 40,000 cycles) merely by throwing a switch which changes the frequency of the fixed-frequency oscillator. In the example given above, if the frequency of the fixed-frequency oscillator was changed to 110,000 cycles, the difference would be 110,000—90,000, or 20,000 cycles. Thus, it is seen that by changing the frequency of the fixed-frequency oscillator the output frequency also is changed.

Oscillators of this type are characterized by very good wave-form, constant output level, lightness and compactness. Their design and construction require great care, however, otherwise they are likely to have poor frequency stability. Other problems of design involve the prevention of interaction between the oscillators, the elimination of harmonics and other undesired frequencies and the prevention of variation in output level.

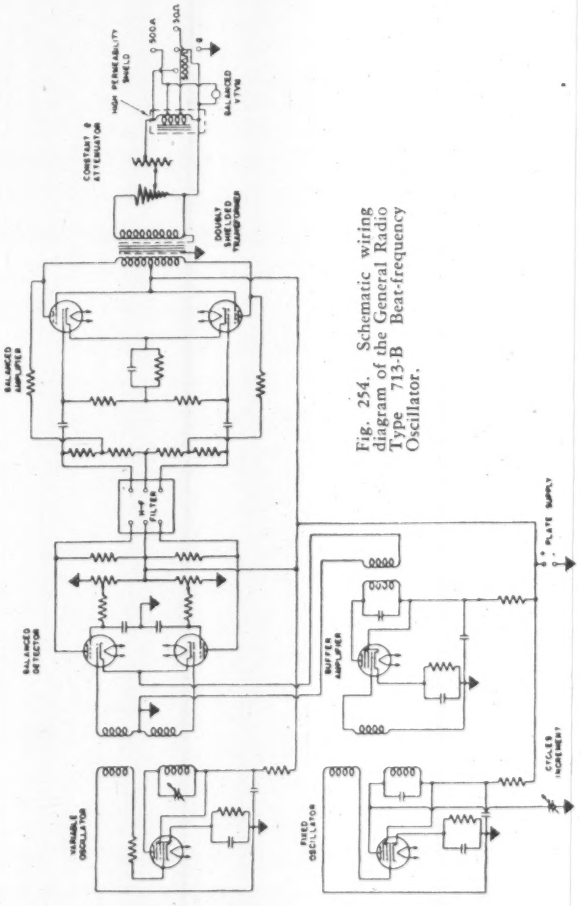
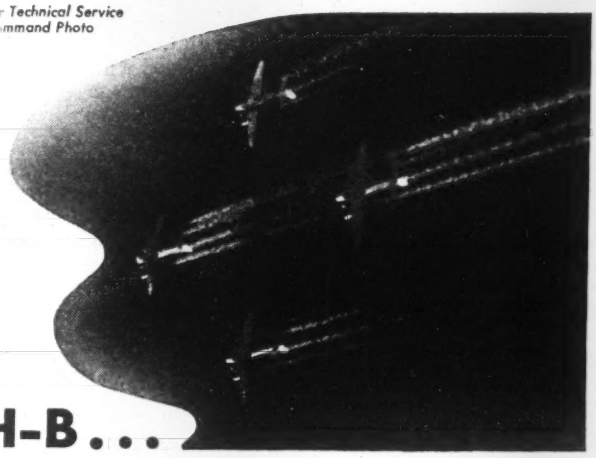


Fig. 254. Schematic wiring diagram of the General Radio Type 713-B Beat-frequency Oscillator.

When two r-f. oscillators operating at slightly different frequencies (as is the case in beat-frequency oscillators) are closely coupled there is a tendency for the two to pull into synchronism. This, of course, would prevent the production of the audio frequency. Such interaction between the oscillators may be prevented in various ways. One, for example, is by the use of the electron-coupled oscillator described in the first part of this article. The electron-coupled oscillator is extremely stable and the frequency is little affected by the load connected to the output circuit. Another method to prevent such interaction is by the use of a buffer amplifier. This is the method indicated in the block diagram shown in Fig. 253, and the method used in the circuit of the General Radio 713B beat-frequency oscillator shown in Fig. 254. This oscillator has a frequency range of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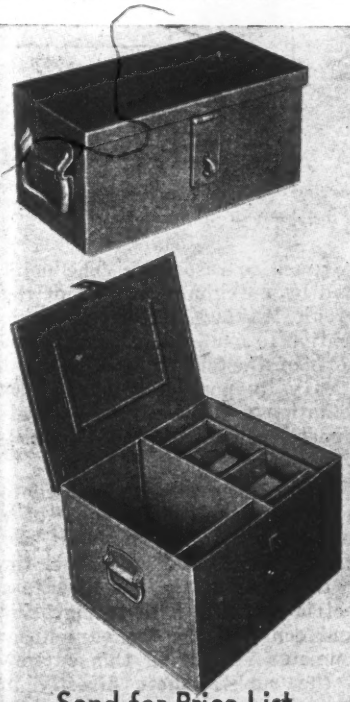

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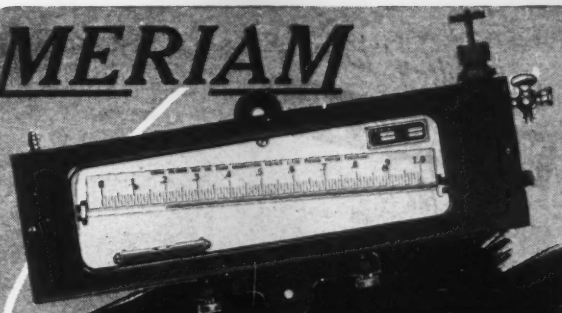

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10 to 40,000 cycles in two steps. The main control of the oscillator is engraved with a logarithmic frequency scale extending up to 20 kc. A switch is provided which shifts the frequency of the fixed oscillator in the manner described and this extends the frequency range up to 40 kc.

The variable oscillator, it will be noted, is coupled directly to the balanced detector but the fixed oscillator feeds into a buffer amplifier and then into the detector. The output of the detector passes through the high frequency filter where the two fundamental radio frequencies as well as the upper side band are removed and then the signal is amplified by means of the balanced degenerative audio amplifier. The output circuit includes a doubly-shielded transformer which couples the output tubes to a constant impedance attenuator and a tapped auto-transformer. The latter provides three different output impedances, namely 50, 500 and 5000 ohms, and is enclosed in a high-permeability shield so that no hum is introduced into the output. The open circuit output voltage of this oscillator is approximately 150 volts while the maximum power output it can deliver to a matched load is slightly over one watt. This oscillator has excellent frequency stability and is designed so there is little frequency drift due to temperature changes.

Electronic Thickness Gages and Moisture Meters

In a preceding article methods were shown whereby electron tubes were used in connection with micrometers to determine the exact point of contact. Another type of electronic micrometer is possible, used as an oscillating-tube circuit.

Fundamentally, the method is very simple. It merely involves the change in capacitance of a capacitor with change in separation of its plates. If a capacitor is connected in series with an inductor to form a tuned circuit, and if this circuit is coupled to an oscillator, as shown in

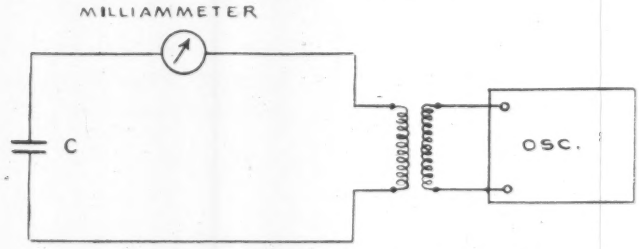

Fig. 255. Principle of the electronic thickness gage.

Fig. 255, the circuit can be tuned to resonance. The point of resonance will be indicated by maximum reading of the ammeter connected in the circuit. At the point of resonance, the circuit is extremely sensitive to changes in capacity of capacitor *C*. Therefore, if one of the plates of *C* is fixed and the other arranged to vary its position with respect to the fixed plate, the combination will constitute a sensitive micrometer. The milliammeter can be calibrated directly in terms of distance or thickness.

This principle of measurement can easily be applied to continuous processes, to the measurement of thickness of a sheet of material, a sheet of rubber for example. If the sheet is passed between the plates of the capacitor, the capacitance varies with the thickness of the sheet because of the variation of the dielectric constant. This changes the impedance of the circuit and consequently the current in the tuned circuit. A milliammeter measuring this current indicates the thickness of the rubber sheet directly in terms of inches or millimeters. If desired, the variation of current in the tuned circuit may be amplified and made to control the thickness of the sheet as it is being made.

In much the same way that thickness can be measured by an oscillating circuit, so can moisture-content be measured. If a rayon ribbon is mounted directly about a sheet of paper as it is being manufactured, the length of the ribbon will vary with the moisture content of the paper. If, therefore, one end of the ribbon is fixed and the other end attached to the movable plate of a capacitor, the cur-

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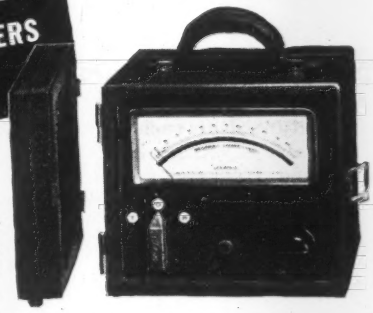

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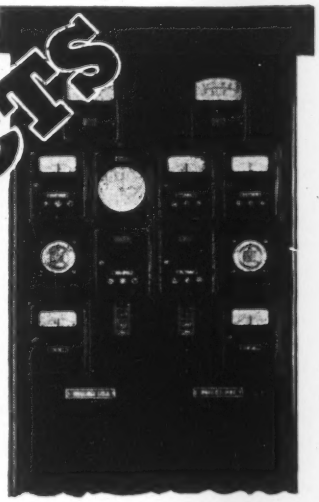

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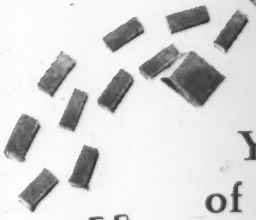

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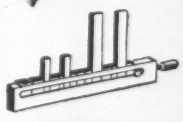

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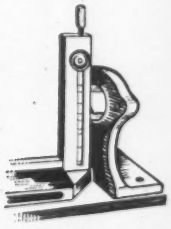

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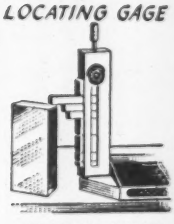

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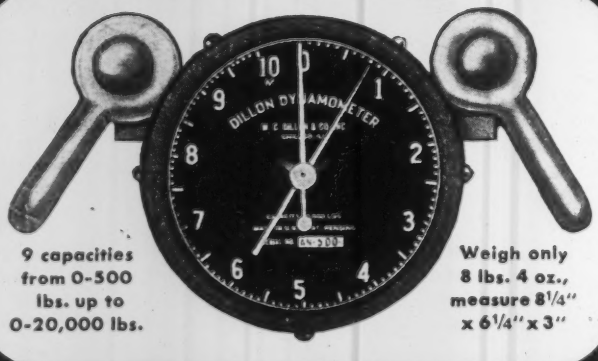

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rent in the oscillating circuit will vary with the moistu content of the paper. In this case the milliammeter is cal brated directly in percent of moisture content.

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The thickness gage also has been successfully applied i continuously measuring the diameter of wire during it manufacture. One such equipment uses a heterodyne osci lator described earlier in this article. One oscillator operate at a fixed frequency; that of the other is made to var with variations in the wire diameter. The resultant bea frequency is amplified and a recording ammeter in th output circuit indicates the variations on the wire dia meter.

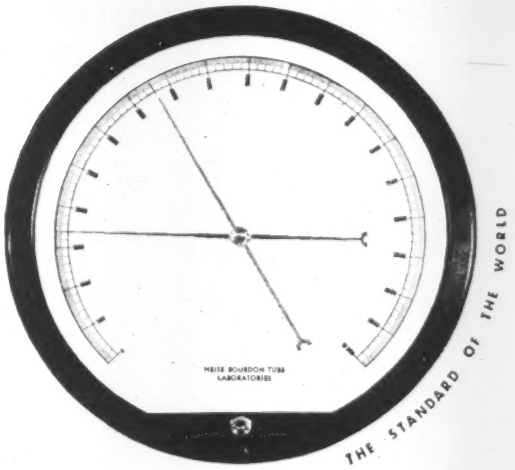
All of these applications, it will be noted, are variation of the same principle. This principle is one of the mos useful in the entire field of electronics, and offers grea opportunity for further application.

XXXIV. CONCLUSION

It is always difficult to write the concluding chapter of a book such as this. The author is conscious of so many things that have not been touched upon, of so many things that have been left unsaid that it seems unjust to the reader to terminate the book without at least mentioning them. This is particularly true of this book. The applications of electron tubes that have been described in the foregoing chapters constitute only a small proportion of the applications of electronics that have been made in the field of instrumentation. Other matters also have been omitted. Little, for example, has been said regarding the use of electron tubes in the regulation and control of industrial processes—the emphasis has been entirely on measurement. Yet measurement and control go together: "*before a condition can be controlled it must be measured.*"* The ramifications of industrial electronic control applications are so extensive, however, so diverse and so numerous that it is impractical to cover the subject along with that of electronic applications in the field of measurement in a single small book. Many of the principles and applications presented here, however, have a direct bearing on industrial control equipment. Consider the wire-thickness recorder described in the last chapter, for example. As described, it was developed to provide a continuous record of the diameter of a strand of wire during the process of manufacture. This is purely a measurement application. It would be only a step further, however, to connect it up with suitable amplifiers and motor controls which would vary the tension of the wire as it passed through dies or the distance between rollers if it were a flat strip instead of a wire. By such means any tendency for the wire to vary in thickness would initiate action whereby the thickness would be maintained constant. The same is true for almost any type of measurement. In the measurement of temperature, for instance, the measuring device usually involves an indicating or recording instrument. If the instrument, by means of such a method as the "hole-in-meter" principle previously described, is made to cut heaters in or out as the temperature varies, we have a system of regulation.

This brings up the question of the difference between regulation and control. These two terms are often misused and not very well understood, yet the difference between them is easily explained. Here it is. Regulation is based on "feedback." Control is not. A regulator tends to keep constant some condition like speed, temperature, voltage or position through a system that automatically corrects errors by feeding the condition being regulated into

*M. F. Behar, "Fundamentals of Instrumentation," Instruments Publishing Co., Pittsburgh, 1932. Preface.



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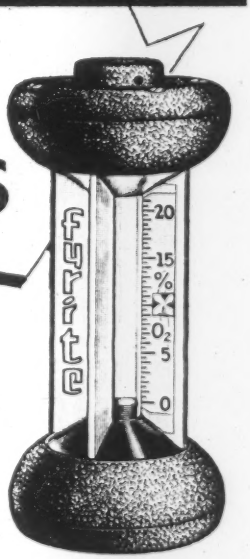

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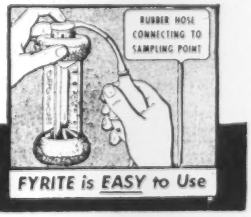

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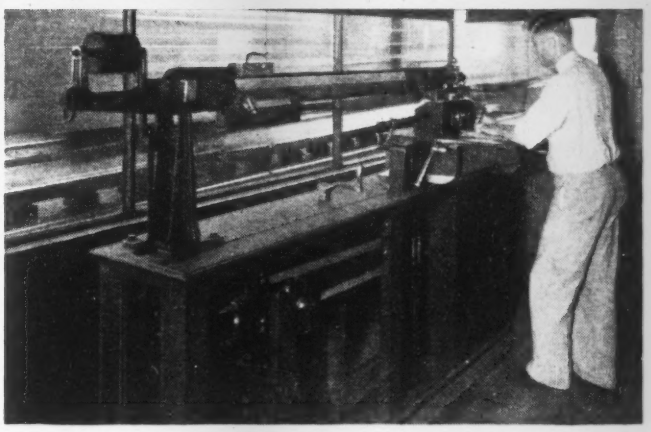

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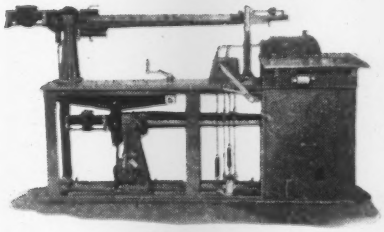

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the system. This is shown in Fig. 256. Control, on the other hand, adjusts a condition through some influence *not connected with that condition at all.* An adjustment like the movement of a rheostat handle by an operator, or the cutting in or out of a time switch are examples of control

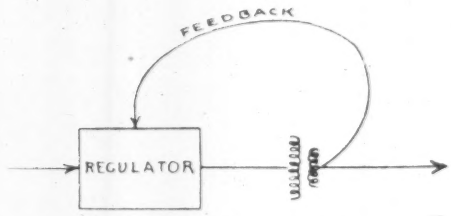

Fig. 256. Principle of regulation.

The detection of improper characteristics of objects or articles on a production line conveyor and the consequent elimination of such articles, through the action of photocells, magnet coils, etc., also constitutes an example of

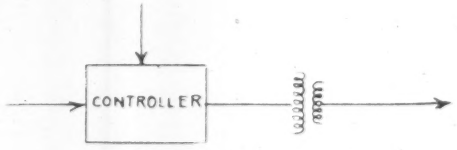

Fig. 257. Principle of control.

control. The principle of control is shown in Fig. 257. Assume that it is the voltage at the load that is to be controlled. An adjuster is provided on the controller by means of which the voltage at the load may be controlled to meet load changes.

Negative Feedback

One of the most important developments in amplifier design in recent years is the use of stabilized feedback as developed by H. S. Black of the Bell Telephone Laboratories. This principle in amplifier design was touched upon briefly in Chapter XXVII in describing the General Radio Type 726A vacuum-tube voltmeter; there it was referred to as degenerative feedback.

Feedback, especially negative or degenerative feedback, is fundamentally an example of regulation. The performance of an ordinary amplifier, especially when high degrees of amplification are necessary, is seriously affected by voltage fluctuations and slight changes in the characteristics of tubes and circuit constants caused by age or temperature as well as other factors. In former years, therefore, it was necessary in most cases to limit the amount of amplification in order to reduce the effect of these factors to a minimum.

All this was changed, however, with Black's revolutionary development of negative or degenerative feedback. In our study of oscillating circuits one aspect of feedback was considered—how, by feeding a portion of the output back into the input of an electron tube circuit, sustained oscillations could be generated. This, it was shown, was the basis of all radio transmitters, but when such transfer of energy took place spontaneously in an amplifier circuit, the result was disastrous insofar as performance was concerned, and neutralizing schemes were necessary.

However, by building an amplifier whose gain is made deliberately, say 40 decibels, higher than necessary (10,000 fold excess on energy basis) and then feeding the output back to the input in such a way as to throw away the excess gain, Black* found it possible to effect extraordinary improvement in constancy of amplification and freedom from non-linearity. By employing this feedback principle, amplifiers have been built and used whose gain varied less than 0.01 db with a change in plate voltage from 240 to 260 volts.

*Stabilized Feedback in Amplifiers, *Proceedings American Institute of Electrical Engineers*, Jan. 1934, page 114.

It is far from a simple proposition to employ feedback in this way because of the very special control required of phase shifts in the amplifier and feedback circuits, not only throughout the useful frequency band but for a wide range of frequencies above and below the band. Unless these relations are maintained, singing will occur, usually at frequencies outside the useful range. Once having achieved a design, however, in which proper phase relations are secured, experience has demonstrated that the performance obtained is perfectly reliable.

The principle of the feedback amplifier is shown in Fig. 258. Regeneration is introduced by superimposing upon the amplifier input a fraction B of the output voltage E, so

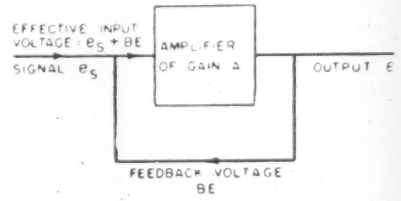

Fig. 258. Diagram showing principle of negative feedback.

that the actual input to the amplifier consists of the signal voltage e_s plus the feedback voltage BE. Since the output voltage E is necessarily A times the voltage actually applied to the amplifier input, $E=A\ (e_s+BE)$.

Without attempting to present the mathematical proof, which is rather complex, it can be stated here that the feedback voltage B opposes the input voltage in phase. The product of the amplification factor A and the feedback voltage B is called the feedback factor and represents the amplitude of the voltage superposed upon e_s compared with the actual voltage applied to the input terminals. Thus if $AB=50$, then for each millivolt existing between the input terminals, and, if the feedback is negative, a signal of 51 millivolts will be required to produce one millivolt at the input.

If the feedback factor is large the effective amplification depends only upon the fraction B of the output voltage that is superposed upon the amplifier and is substantially independent of the gain actually produced by the amplifier itself. This remarkable behavior is a consequence of the fact that when the feedback is large the voltage actually applied to the amplifier input terminals represents a small difference between relatively large signal and feedback voltages. A moderate change in the amplification A therefore produces a large change in the difference between signal and feedback voltages, thereby altering the actual input voltage in a manner that tends to correct for the change in amplification.

The importance of negative feedback can scarcely be over-emphasized. Before feedback was developed, the output of all electron-tube devices, more or less independent of circuit arrangement, was greatly affected by the plate and filament supply voltages. In some cases a 10% change in plate voltage would cause a 20% change in output even if the input remained constant. With the development of feedback almost unlimited improvement in stability and regulation became possible. With many of the new feedback circuits, variations of output with changes of plate or filament voltage are reduced to 10 or 20% of their former values, using simple and practical arrangements. With special precautions much greater improvement is possible. Indeed, a number of manufacturers have recently brought out electron-tube measuring instruments that are accurate within 1 or 2% when supplied from the ordinary 110-volt 60-cycle system without regulating devices of any kind. A few simple feedback circuits are shown in Fig. 259 but the principle is applicable to almost any type of amplifier circuit.

Negative feedback also tends to reduce harmonic distortion arising in the plate circuit of the amplifier. This distortion is present in the amplified output voltage, but not in the original signal voltage applied to the grid. The voltage fed back to the grid circuit contains the distor-

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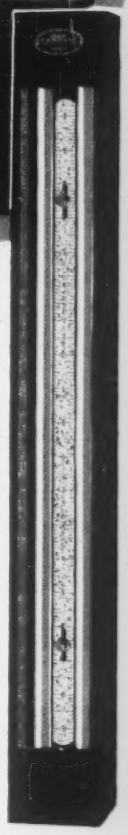

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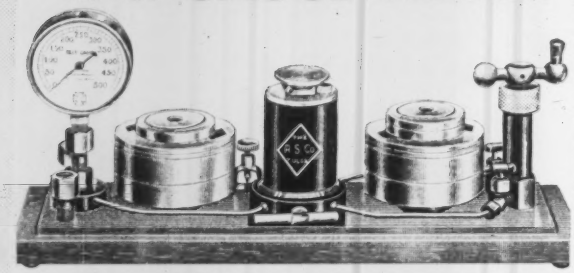

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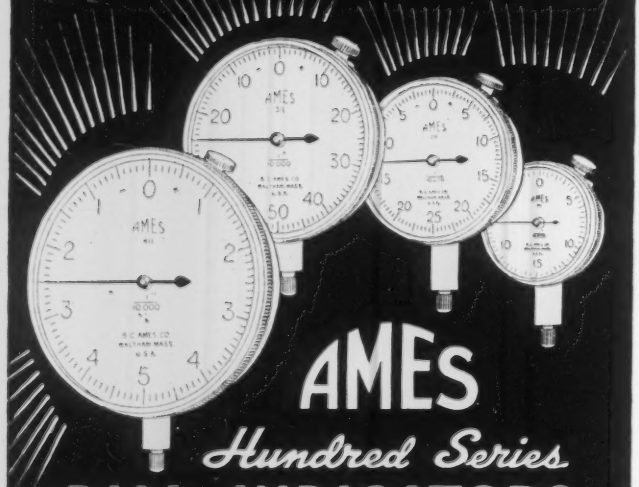

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tion but in opposite phase to the distortion components in the plate circuit, therefore, the two tend to cancel each other. For similar reasons, the overall amplification is less dependent upon the value of load impedance used in the plate circuit; in fact, if a large amount of negative feedback is used in an amplifier it is even possible to substitute tubes of rather widely different characteristics without

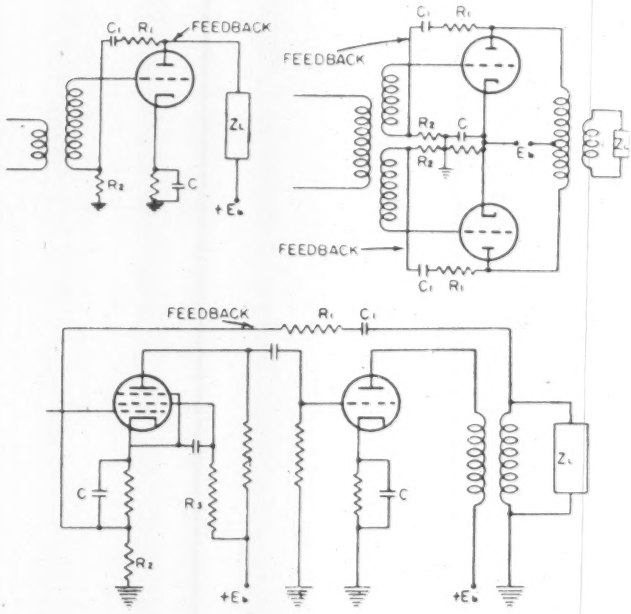

Fig. 259. Amplifier circuits using negative feedback.

much effect on the overall performance. Both positive and negative feedback may be applied over several amplifier stages of an amplifier, rather than being applied directly from the plate circuit to the grid circuit of a single tube; this type of feedback is shown in the bottom diagram of Fig. 259.

These remarks concerning regulation and control are introduced here to show how certain simple fundamentals serve to explain the difference between whole classes of application. If the fundamental difference between "control" and "regulation" is fully understood, it becomes unnecessary to describe in detail all the various types of control and regulating devices.

The aim of this book is not so much to make the reader an expert in the use of tubes or to show him exactly how to meet any particular problem, as it is to make him conscious of the power of the electron tube and to indicate how it may prove useful. Each class of instruments described should suggest others. The development of electronic devices and their application demands a certain amount of enthusiasm on the part of those who are in a position to authorize such development work and it is partly the purpose of this book to stimulate such enthusiasm.

The material presented must be considered only as an introduction to the subject of electron tubes. The treatment is in no way intended to be exhaustive. Its purpose is to stimulate further interest in the subject. What is said here is extremely simple. In its deeper phases, electronics can be extremely complex but reduced to its fundamentals the electron tube is a very simple device and its operation can readily be grasped by any intelligent person.

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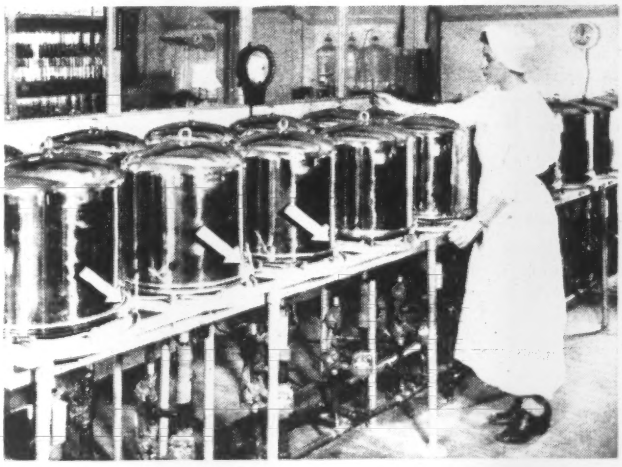

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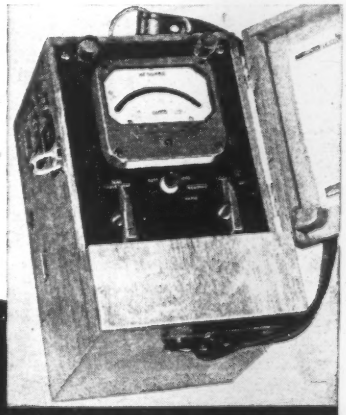

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Battery-Vibrator type requiring no tiresome hand-cranking of a generator; with spillproof built-in storage battery, rechargeable from either AC or DC line voltages. Portable, entirely self-contained. Direct reading in megohms and ohms; hand-calibrated meters with mirror scale for split hair accuracy. Guard circuit. Steady pointer indication. Rugged, highest quality construction. Ranges 0-200 megohms, or 0-100/0-1000 megohms with additional ohm scales.

FOR FULL DETAILS WRITE FOR BULLETIN No. 445

HERMAN H. Sticht COMPANY, INC.
27 PARK PLACE, NEW YORK 7, N. Y.

Plug in

METAL TUBE RESISTORS

★ Clarostat pioneered the plug-in metal tube resistors found today in many compact AC-DC radio sets. These handy resistors serve as voltage reducers and also as resistance networks for supplying a plurality of voltages. Clarostat also makes voltage regulator ballasts in perforated metal cases, either as plug-ins or for permanent mounting.

If you are seeking such handy, accurate, dependable resistors for your electronic or electrical assemblies, please bear in mind that Clarostat means outstanding experience, engineering and production facilities.

★ **Consult Us . . .**

Send those resistance, control or allied problems to us for engineering collaboration, specifications, quotations.

ARMY E NAVY

CLAROSTAT *Controls and Resistors*

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

Coil and Scale Ratings

(Concluded from Page 79)

reaching the best compromise between conflicting elements.

VOLTAGE CONDITIONS

The potential circuits of a-c. instruments are designed with a certain marginal allowance for intermittent overvoltage, or for high ambient temperature operating conditions. This margin of safety should not be considerably reduced by cutting out resistance in efforts to change the ratings of existing instruments, without a careful analysis of the effect, or without trial. Different makes and types of wattmeters and voltmeters differ in these respects and what might be possible on a recent model of one make might be disastrou on an earlier type or on some othe make. It is of course safe to increas the voltage resistance as required, t increase the full-scale capacity, whe this would not cause the current coil to be overloaded.

In general, requirements for possibl reduction in resistance values, to secur increased readings or reduce full-scal capacity, should be referred for decisio to the manufacturer of the instrument In certain cases the problems may b met in one way or another; sometime moving coils of different values can b put in, but such extensive changes ha better be confined to the manufacturer's shop, where specialized tool equipment is available.

PERMOPIVOTS

Wear Resistant
Non-Abrasive

Non-Corrosive
Non-Magnetic

Extraordinary long range benefits accrue from PERMOPIVOT installation: Accurate performance of precision instruments—l-o-n-g-e-r! . . . Ask for descriptive literature.

PERMO, Incorporated

Manufacturing Metallurgists

6423 RAVENSWOOD AVE. · CHICAGO 26, ILLINOIS

Do you want ACCURACY in Making Moisture Tests?

Accuracy is a prime factor in moisture testing . . . and the Steinlite one minute moisture tester is consistently accurate. It is built by a pioneer staff of radio engineers . . . operates on the radio frequency impedance principle . . . and is calibrated against the official method for each product. The fact that more Steinlites are in use than all other makes of electrically operated moisture testers indicates that industry recognizes the accuracy of the Steinlite.

It is neat, compact, light and portable. It is economical to operate . . . consuming no more electricity than a 40-watt bulb. It is successfully used on gun powder, cocoa, dehydrated foods, grain and a host of other products.

Ask our Engineers to help solve your moisture testing problem.

The STEINLITE One Minute Moisture Tester

644 BROOKS BUILDING
CHICAGO 6, ILLINOIS

SEEDBURO
EQUIPMENT COMPANY

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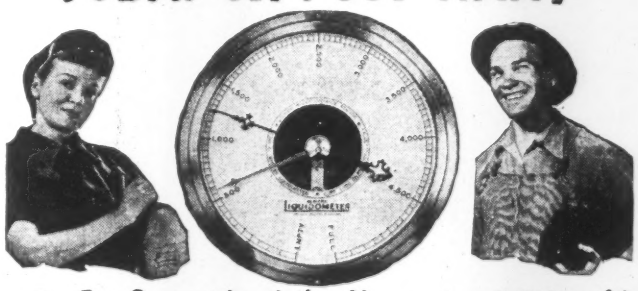
TODAY OR POST-WAR!



It Is Important to Measure Valuable Stored Liquids Accurately With –

LIQUIDOMETER *Tank Gauges*

"THEY'RE ALWAYS DEPENDABLE"

100% automatic.
No pumps, valves, or auxiliary units needed to read them.
Models for either remote or direct readings.
Accuracy unaffected by specific gravity of tank liquid.
Approved by Underwriters' Laboratories for gauging hazardous liquids.

Write for complete details

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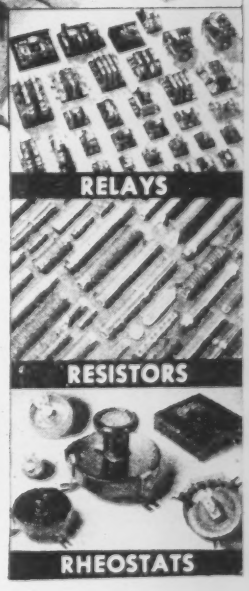
36-27 SKILLMAN AVE. · LONG ISLAND CITY, N. Y.

CONTROLS *FOR POSTWAR PRODUCTS*

With the rush to catch the earliest possible markets with postwar products, it is important that they be designed with units that can be procured without undue delay. Manufacturers of equipment requiring electric controls will find Ward Leonard Relays, Resistors and Rheostats readily available without "time-out" for redesigning. Let us send you bulletins describing controls of interest to you.



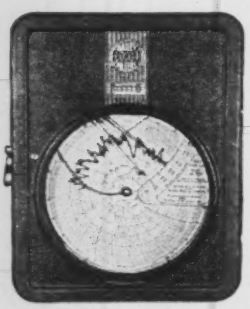
WARD LEONARD
RELAYS • RESISTORS • RHEOSTATS
Electric control (WL) *devices since 1892.*

WARD LEONARD ELECTRIC CO.
38 SOUTH ST., MOUNT VERNON, N.Y.

BAILEY METERS

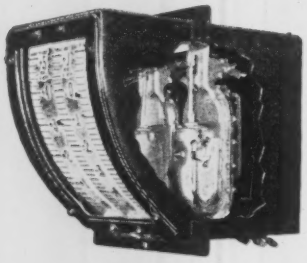
METERS and CONTROL
for Boiler Room Service . .

Boiler Meters Reduce fuel costs, lessen maintenance and outage, lower standby costs, and add capacity. They indicate, record and integrate Steam Flow from the boiler, record Air Flow supplied for combustion and record Flue Gas Temperature.



Bailey Boiler Meter

Multi-Pointer Gages for indicating drafts, pressures, differentials are available with any number of pointers from one to twelve. They are actuated by sturdy yet sensitive diaphragm units.



Multi-Pointer Gage

Flow Meters. For indicating, recording and integrating the flow of steam, feed water, compressed air and other fluids.

Coal Meter

Granular Material Meters For accurately measuring the flow of coal or other granular materials in gravity chutes from overhead bunkers. The total quantity of granular material is shown on a large illuminated counter which may be easily read at a distance of 50 feet.

Control Systems Make possible the everyday operation of equipment for steam generation and utilization at test efficiencies. They are applied to the control of combustion, feed water, superheat, desuperheat and other factors.

Complete Information on any of the above Bailey products will be gladly furnished upon request.

G-14

BAILEY METER • COMPANY •

1041 Ivanhoe Rd., Cleveland, Ohio

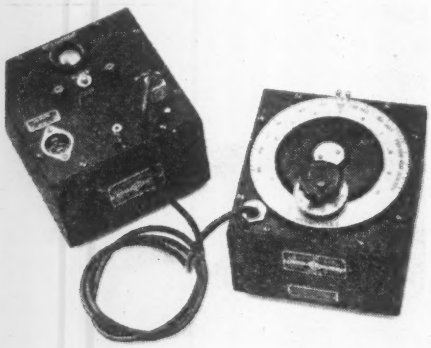
BAILEY METER COMPANY LTD., MONTREAL

The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

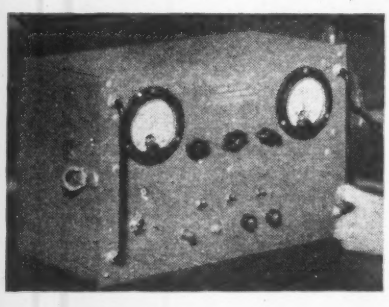
100-500-Mc. Oscillator

New "Type 857-A" ultra-high-frequency oscillator covers a frequency range of 100 to 500 megacycles. Designed for use as a power source for laboratory measurements, its maximum output is ½ watt or better over the entire frequency range. Frequency-determining element in this oscillator is a "butterfly," a new type of high-frequency tuned circuit developed by General Radio. In the butterfly, inductance and capacitance are varied simultaneously with a single control and no electrical contact to the moving element is necessary. Dial reads directly in frequency with an accuracy of ±1%. A slow-motion drive is provided. Output circuit is inductively coupled to the oscillator and output is controlled by varying the coupling. Output terminal is a coaxial jack. "Type 857-P1 Power Supply," supplied with the oscillator, furnishes filament and plate power and operates from a 115- or 230-volt a-c. line, 42 to 60 cycles. An electron-ray tube is used to indicate oscillation. Oscillator is 6⅛" × 7⅝" × 7¼" overall and weighs 6¼ lbs. Dimensions of power supply unit are 5½" × 6⅝" × 7⅝", weight 9½ lbs.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*



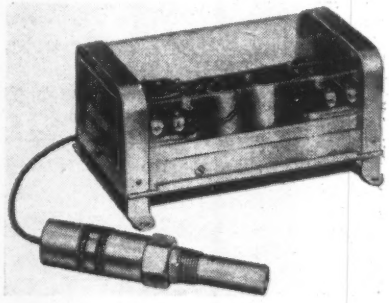
Mercury-vapor Detector

New model of G.E. mercury-vapor detector represents several refinements by company which has specialized in this field. New instrument can perform quantitative measurements of concentrations around toxic limit (12 parts Hg vol. p. 10^7 air) to approx. 5% accuracy whereas original non-indicating selenium-monosulphide model required a skilled operator and 1935 Se instrument (*Instruments*, March 1936, page 61) requires renewing treated paper. New detector is third in series of company's detectors employing resonance-radiation method and its ultimate sensitivity is one order of magnitude higher. First model (*Instruments*, Nov. 1933, page 211) detected 1p.p. 10^8; second (*Instruments*, Feb. 1939, page 62) 1p.p.10^9; new model's ultimate sensitivity is 10^{10} and it *measures* at 5p.p.10^9 which is <0.5% of toxic limit. Concentration of Hg is measured by an atomic (not electronic) phenomenon; measuring system comprises an ultraviolet lamp and a photo tube, on opposite sides of an absorption chamber through which 0.25 to 0.5 c.f.m. of air is drawn. Both lamp and tube have spectral curves with maxima near the 2536 A.u. principal Hg line, so that ordinary un-ionized Hg atoms in continuous sample of air absorb this monochromatic radiation and, even in low concentrations, reduce phototube current measurably. By means of a bridge circuit, drop in phototube current is translated into an upscale reading on indicating instrument of detector. An important refinement over previous resonance-radiation models is that this new one is said to be "instantaneous" in its indication.—*Special Products Div., General Electric Co., Schenectady, N. Y.*



Non-hunting Temperature Controller for Aircraft Applications, etc.

New "Modutemp" is an automatic temperature controller for aircraft oil coolers, coolant radiators and heating systems. Its operating principle is described as a temperature gap formed by two electrical contacts in a mercury thermostat which control individual relays. Contacts are set to meet temperature specifications and range of individual requirements. When mercury falls below temperature gap, damper motor runs toward heat position and both relays apply electric heat to the thermostat to assist mercury to rise again into gap. When mercury enters gap motor operation stops and heat from No. 1 relay cuts off, slowing down rise of mercury. Damper holds this static position until mercury moves out of temperature gap between the two contacts. If mercury rises above gap damper motor



Higher THAN A PLANE CAN FLY

Lower THAN A SUB CAN SUBMERGE

The high-to-low instrument testing range of Bowser-built Testing Chambers is considerably greater than can be obtained with the highest practical actual flight plus the greatest submerging depth. This permits a tested and proved safety factor—a priceless asset.

That's one big reason why instrument makers are turning more and more to Bowser-built Test and Calibration Chambers, which have demonstrated their efficiency and practicality time after time in actual operation.

There are other big reasons, too. For instance, chamber testing is much less costly—no expensive personnel, motor fuel, etc. In fact, a Bowser Chamber costs probably less than testing a bomber one hour under actual flight conditions. Moreover, chamber testing is much quicker and immeasurably safer.

Aggressive manufacturers are installing testing chambers . . . not relying on laboratories already burdened with research work. Write for complete information or, better still, our engineers will gladly consult with you.

BOWSER, INC.

Mobile Refrigeration Division

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BOWSER ESTABLISHED 1885

Not only has Bowser's war production earned the Army-Navy E... Bowser equipment has helped earn it for scores of other companies.

MOBILE REFRIGERATION DIVISION NEW YORK

BUY WAR BONDS

THE NAME THAT MEANS EXACT CONTROL OF LIQUIDS

AGE is important

in fine violins...

and in fine

rectifiers

While some ordinary rectifiers require a period of "ageing," under operating conditions, to attain the stable characteristics necessary for correct instrument applications, this is *not* true of the CONANT family of rectifiers.

CONANT rectifiers, when they reach you, have already "become of age," electrically. Part of the CONANT process is devoted to developing, by chemical means, the stable characteristics ordinarily secured by a time-consuming "ageing" period.

Yet, despite their "ripe old age," you'll be amazed to find CONANT rectifiers surprisingly "spry" and ready to give you years of reliable service. For your present needs or your postwar plans, you can COUNT ON CONANT.

Instrument Rectifiers

CONANT **ELECTRICAL LABORATORIES**

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600 S. Michigan Ave., Chicago 5, Ill.
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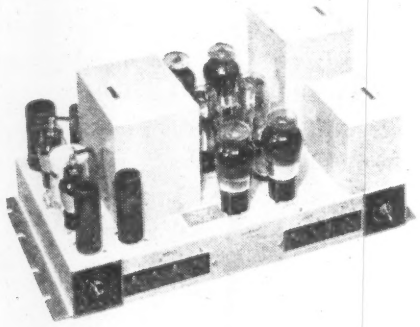
7935 Eustis St., Dallas 18, Texas
4018 Greer Ave., St. Louis, Mo.
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal.
4205 N.E. 22nd Ave., Portland 11, Ore.
Caixa Postal 930, Sao Paulo, Brazil
50 Yarmouth Rd., Toronto, Canada

operates toward cool position and No. 2 relay cuts off remaining heat on thermostat tending to make mercury fall and enter gap stopping damper movement. It is said that "Modutemp" never hunts, is compact and light in weight (aircraft type weighs only 25 oz.). System may be specified to handle various sizes of motors. Where hydraulic or pneumatic power is used, "Modutemp" controls through operation of solenoid valves. Damper positions at any point necessary to satisfy the thermostat and not limited to steps or set number of degrees of movement.—*Vapor Car Heating Co., Inc., Railway Exchange, Chicago 4, Ill.*

Medium-gain Amplifiers

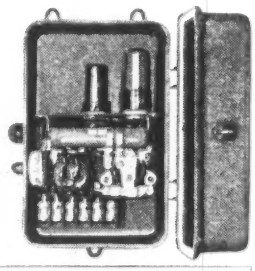
New series of medium-gain high-power bridging amplifiers, known as "101 Type," are designed for commercial continuous service. Where increased power is desired

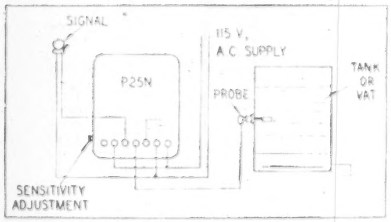


any number may be bridged across busses from 1 to 1000 ohms. Therefore, it is said, a complete amplification system of high quality and great flexibility is provided when used in conjunction with a program or line amplifier such as maker's "102" series. All models in new "101" series will deliver 50 watts to a nominal load impedance with less than 3% r.m.s. harmonic distortion at 400 cycles. Gain control provides continuous adjustment over a 40-db range and bridging connections. Chassis are 16 gage welded steel, zinc-plated and bonderized. Finish light gray baked enamel. Weight approx. 45 lbs.—*The Langevin Co., Inc., 37 West 65th Street, New York City.*

Concentration Controller

New "Type P25N Electronic Concentrate Control" is for detecting and controlling, through operation of signals, valves or pumps, changes in liquid concentration; is designed for applications in which changes in concentration are accompanied by corresponding changes in electrical conductance. Installation is said to be made quickly and

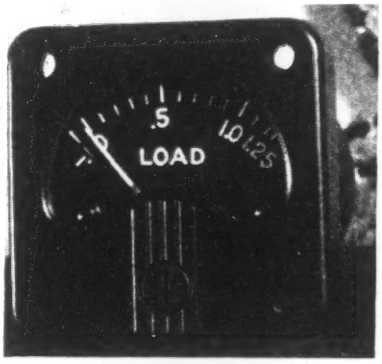




...ily: probe fitting is mounted on tank ...ith probe extending into liquid) and is ...ed to control unit which may be located ...erever desired. An adjustment on control ...using is set so that control relay will ...erate when liquid of a predetermined ...ctrical resistance contacts the probe: ...en a change in concentration alters con...tance of liquid to necessary degree, ...ctronic control relay is energized to op...te signals, valves or pumps. New "Type ...5N" is used also wherever it is necessary ...maintain an interface between two liquids ...fering "even slightly" in electrical con...tance, thereby making possible single or ...o-level control of one liquid within a tank, ...en though another liquid may be above ...below it. New "Type P25N" has a sensi...ity range of 100 to 5,000 ohms and oper...es on a 5% change in probe-circuit re...stance. Predetermined resistance value for ...hich control is set remains fixed regardless ...variations in line voltage or tube char...teristics. Voltage applied to the probe ...ver exceeds 25 volts, thereby eliminating ...ny possibility of electrical shock or ex...plosion hazard. "Type P25N" incorporates ...p. d-t. relay rated at 10 amps. a.c., 5 ...mps. d.c., for normally-closed and normal...-open operation, and requires a supply of 115-volt 60 cycle a.c.—*Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.*

Miniature Ammeter for Aircraft

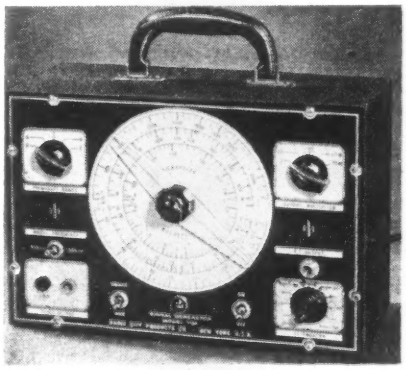
New miniature ammeter is said to do with almost no sacrifice, in 1¾" square, what previous 2½" and 3½" square instru-



...ments have done. It was originally designed for the B-29 Superfortress. Instrument weighs 4 oz., a saving of 79.1%, uses many of the same parts as the larger one: moving element is identical, other parts are smaller. Dial is 1.2" long instead of 1.8" for the 2½" instrument—*Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*

Signal Generator

New "Model 704" signal generator is a complete wide-range instrument said to meet broad requirements of today's testing with great accuracy and stability. Range



A New Electronic FLUXMETER

By HICKOK

For Comparing Flux Density in Magnetic Fields

● Here is a modern and versatile electronic instrument for the comparison of flux density, in all types or shapes of permanent or electro magnets. The flux density is read on the indicating meter while the coil remains at a fixed point in the field. The device is static. The field strength is amplified so that a rugged meter may be used to insure dependability and accuracy. It is fast and very simple to operate.

Weak magnets can be quickly and accurately classified. Aging by vibration, counter-magnetic fields, temperature, variations in grain structure and hardness, etc., are readily shown on the Hickok Fluxmeter.

By a suitable stationary exploring inductor, the Fluxmeter provides a rapid means of measurement on any assembled product. The field of a loud-speaker, the flux density in the air gap of assembled meters; and either disc or bar type magnets can be readily ascertained. Used to measure both A.C. and D.C. fields. Write for literature.

THE HICKOK ELECTRICAL INSTRUMENT CO.

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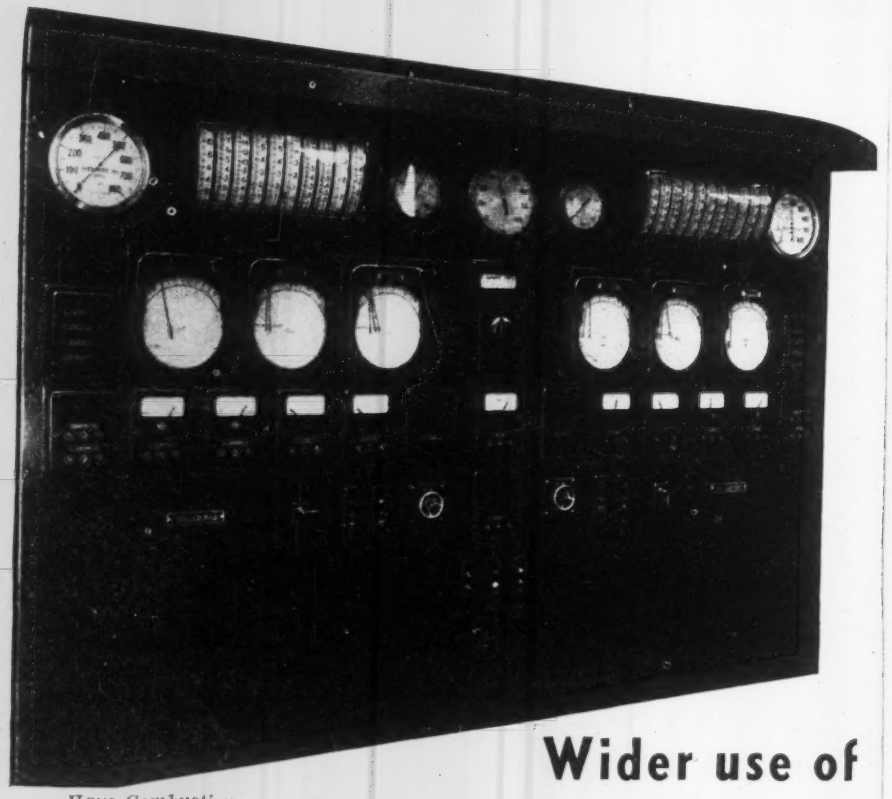
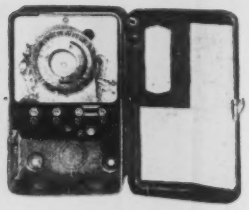
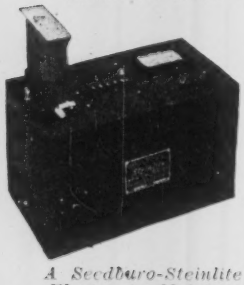


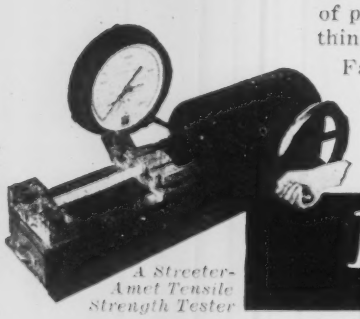
Hays Combustion Control Instruments



A Paragon Industrial Timer



A Seedburo-Steinlite Electronic Moisture Tester



A Streeter-Amet Tensile Strength Tester

Wider use of Instruments will speed up Industrial Progress

Today the demands upon industry are legion. Tomorrow, they promise to be more numerous and more exacting. To meet those demands and accelerate industrial progress requires an expanding use of instruments . . . instruments in production and plant operation . . . not in the laboratory alone . . . instruments that control . . . indicate . . . test . . . measure . . . or inspect.

INSTRUMENTS ELIMINATE GUESSWORK . . . by supplying vital information . . . data . . . facts.

INSTRUMENTS SAVE MANPOWER . . . by reducing the human effort required to perform innumerable operations.

INSTRUMENTS IMPROVE QUALITY . . . in foods, chemicals, soaps and other products by providing precise measurement of ingredients.

INSTRUMENTS REDUCE COSTS . . . by promoting economy in the use of fuel, by automatically controlling timed operations, by quickly indicating the moisture content of grain, by showing the strength of plywood in process and by doing a hundred other things.

Farsighted is the executive who keeps abreast of the most advanced use of instruments in his field . . . instruments which control, indicate, test, measure or inspect.

Instruments

THE MAGAZINE OF MEASUREMENT AND CONTROL

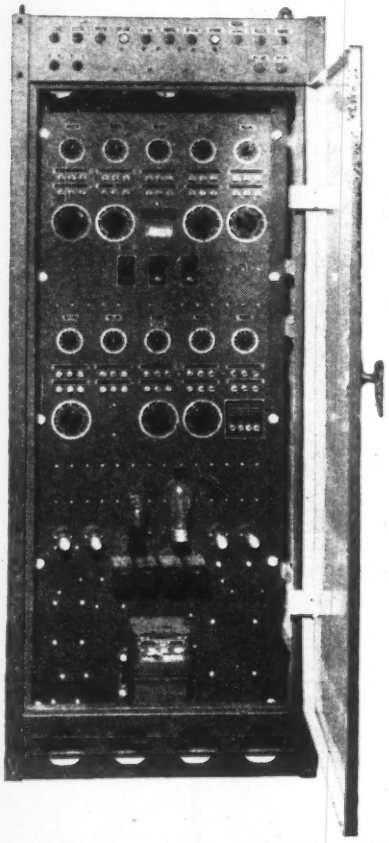
THE INSTRUMENTS PUBLISHING COMPANY 4119 WOLFENDALE STREET • PITTSBURGH, PA.

This advertisement was prepared for INSTRUMENTS *by Gebhardt and Brockson, Inc., Chicago, advertising agency for Hays Corporation, Michigan City, Paragon Electric Company, Chicago, Streeter-Amet Company, Chicago, Seedburo Equipment Company, Chicago.*

is from 95 kc. to 100 Mc. Fundament frequencies are continuously-variable fro 95 kc. to 25 Mc. in 5 bands. Calibrati is accurate to 2% per band up to broa cast band and within 3% for high-fr quency bands. Capacitor is planetary driv with direct-reading calibration. Output c be modulated or unmodulated. Self-co tained modulation is either 400 cycles 1,000 cycles sine wave which modulat carrier. Either is available for external us Protective features are: automatic shortin of all coils not in use; individual shieldin of r-f. circuits, coil assembly and attenu tor; overall steel case, chassis and pane Five-step ladder attenuator is used for co trolling output. "Model 704" has a conve ient pilot-lamp on-off indicator and a doubl fused line cord. Instrument is availabl complete, ready for use.—*Radio City Pro ucts Co., 127 West 26th Street, New York N. Y.*

Weld and Sequence Timer

New "Type CR7503-F170" weld and s quence timer, for providing time and cu rent adjustments necessary for weldin heavy sections of air-hardenable steels, is especially designed for use with a G-E ignitron contactor and a heat control pane

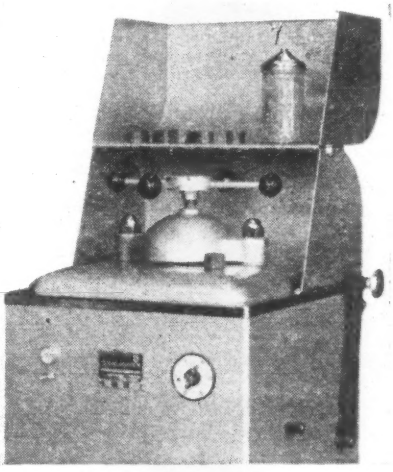


but can also be used in combination wit most G-E spot-welding controls utilizin phase-shift method of heat control. Operat ing from 230/460/575 volts, 60 cycles, uni adjusts current and time for preheatin welding, grain refinement, and temperin Other adjustments control time for chillin weld nugget following weld and grain-re finement periods. For variations in contro voltage of +10% to —20%, consistency o timing will be within ±0.5% of time settin However, manufacturer recommends that G-E current-regulating compensator be use with this combination to correct for varia tions in welding current caused by line volt age variation or introduction of magneti materials into throat of welding machin Unit consists of nine time intervals, seve independent heat adjusters, two pressu interval timers, one squeeze timer, one hol timer, and provisions for a two-stage fo switch, all housed in a steel enclosure. Co

ol adjustments are on front of panel and ch timer has a separate time adjustment d an "in operation" indicating light. Heat ntrol knobs have large graduated dials. spite multiplicity of operations required, ly six electron tubes are used.—*Industrial ntrol Div., General Electric Co., Schenectdy, N. Y.*

Specimen Mounting Press

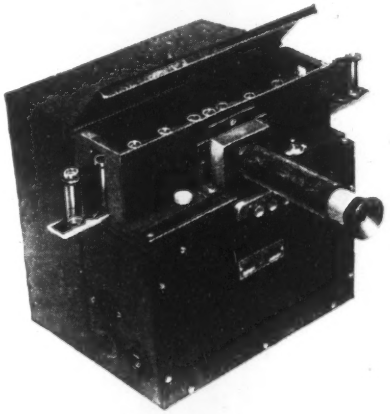
New Semi-automatic Air-operated Specien Mounting Press is radically new design. Air is automatically set by a nstant-pressure reducing valve, eliminat-



ng hand-operated hydraulic jack customarily used to maintain pressure on specimens while curing. This feature is said to assure uniform specimens identical in size and hardness, improve polishing characteristics, and greatly reduce operator's time. Note: Illustration shows upper part only.—*Precision Scientific Co., 1750 N. Springfield Ave., Chicago 47, Illinois.*

Optical Fluorescence Comparator

New "Photovolt Optical Fluorescence Comparator" is designed for quantitative chemical analysis by fluorescence, permits comparing intensity of fluorescence of solutions and determining concentration of

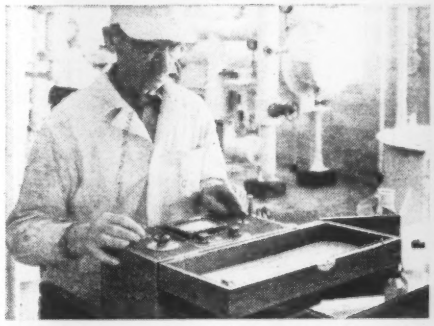


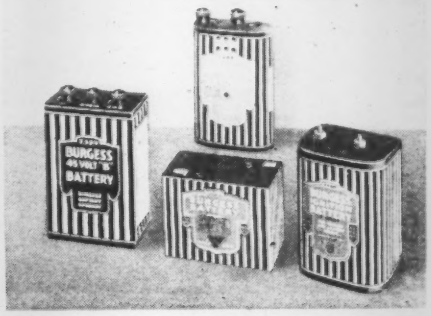
fluorescent substances. Specifically, it serves to indicate the place which an unknown takes in a series of standards (solutions of known concentrations). Sensitivity of measurement is said to be so high that minute quantities can be reliably determined. The instrument is simple in operation and does not comprise any delicate parts. It is suitable for use under any temperature and humidity conditions and can be operated from any power line regardless of voltage and frequency fluctuations. Procedure for measuring concentration is similar to that employed in visual color comparators: fluorescent standards of known

PORTABLE POWER PROBLEMS

THIS MONTH—COMMERCIAL SOLVENTS CORPORATION PENICILLIN TEST

LIFE-SAVING PENICILLIN salt solution is carefully tested by *battery-powered* pH meters before it is placed in vials by white-clad technicians at the modern Commercial Solvents Corporation plant. Throughout the entire manufacturing process, rigid pH checks against excess acidity and alkalinity must be maintained while the penicillin is in solution.





FOUR pH METERS, powered by Burgess Industrial Batteries, are employed by Commercial Solvents Corporation on a 24-hour a day basis to assure necessary, uniform product control. Burgess Industrial Batteries are built to meet specific requirements of test and control instruments. Whatever *your* portable power problem may be, Burgess engineers are equipped to find the answer. Write us today about your needs, or request free, 80-page Engineering Manual on dry batteries. Dept. 4. *Burgess Battery Company, Freeport, Ill.*

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concentration are filled into vials and these are inserted, in order of increasing concentration, into sliding rack so that one space is left open between each two. Vial with the unknown is inserted into the space between two standards and the three vials are viewed. If brightness of unknown is found not to be equal to one of standards and not to lie between their brightness, rack is shifted and the unknown is inserted into the next gap. This step is repeated until the unknown is found either equal to one of the standards or between two. Instrument's triple-field speeds evaluation of samples, also makes it possible to increase the accuracy of readings by estimating fractional steps or by using sets of standards of smaller increments. The 500-watt incandescent lamp is turned on only during the time of actual measurements; it is operated by a push-button in front of instrument. This insures long lamp life and minimizes heat. The 100-watt mercury lamp is turned on permanently during operation; its heat is comparatively small. In addition, a powerful ventilating blower is automatically turned on when either incandescent lamp or mercury-vapor lamp is being used; lamps cannot burn without blower operating. A large, accurately-ground collimator provides parallel light beams of equal intensity through the three vials. Bottoms of vials are ground and polished to optical flatness so that parallelism of beams is maintained through the liquid. As a result of this careful optical design, non-fluorescent solutions (blanks) *appear perfectly black* when viewed through eyepiece. Operator can, at any time, verify that exciting light is of the same intensity in all three fields; and if, for instance, lamp is not accurately in focus, brightness of fields can be equalized by means of three knobs on front of instrument. These can be locked by set screws; readjusting necessary only after installing new lamp. Instrument is furnished with a rack having 11 spaces for vials: 6 standards and 5 spaces for unknowns. A 21-space rack is available. Twelve selected vials, with bottoms ground and polished, are furnished with instrument. Additional vials are available. Liquid volume to be filled into the vials is 5 ml. or more; actual quantity is not critical inasmuch as, with 5 ml. or more liquid level is outside viewing field. *Model* "Model 50" is furnished with 500-watt incandescent lamp and with the standard primary filter for this light source. It is equipped with an additional socket for the mercury-vapor lamp and with outlets to connect auxiliary transformer. Mercury lamp with transformer available as accessories. The primary filter recommended for mercury light is furnished together with mercury lamp and transformer. "Model 5" is provided with auxiliary transformer for mercury lamp built into instrument housing. It is furnished with incandescent lamp and mercury lamp, and with the two primary filters for the two light sources. For fluorescence tests requiring shorter exciting wave bands, special mercury lamps can be used such as low-pressure lamps with strong emission at 253 mμ or high-pressure lamps without glass envelope having various emission bands down to 240 mμ. Special auxiliary transformers are furnished with these lamps. For operation in medium and far ultraviolet, Comparator can be equipped with quartz lens, special deflecting mirror, and special vials for low ultra-violet absorption.—*Photovolt Corp., 95 Madison Ave., New York 16, N. Y.*

We Cannot All Be Heroes and Win Fame

but it takes a steady worker like RUBY, who dreams of gallant ladies, as she graduates those fine lines on a waxed tube, so it will be accurate when used to test manufacturing processes of war materials.

And in your post-war plans, just remember, it will take the same steady skill to produce GOOD Thermometers that you will need in your plant.

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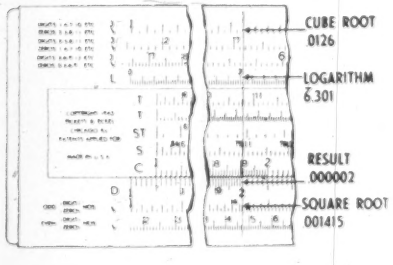
Low-Resistance Test Sets

Two new Low-Resistance Test Sets, "Type 645" (Army range) and "Type 653" (Navy range) include all features of previous models with the added convenience of complete portability and greater freedom, ease, and speed of operation. Test unit containing indicator, batteries, switches, control, etc. is supported in front of operator by means of adjustable shoulder straps. Bond or contact resistance measurements as low as 0.0001 ohm can be made by attaching the fixed clamp to one side of the bonded surface, then touching hardened points of "Pistol Grip Exploring Probe" to other side. It is said that both hands are free at all times to adjust and operate the instrument. Weight of the pistol grip probe is minimized because indicator, batteries, etc., are in cabinet. New sets are said to be unexcelled for testing railroad bonds, radio equipment, contact resistance of relays, circuit breakers, switches, etc. They make bar-to-bar resistance measurements on commutators as simple as making a voltmeter reading. "Type 645" (Army range) is 0.005 and 0.5 ohm full scale. "Type 653" (Navy range) is 0.003 and 0.3 ohm full scale.—*Shallcross Mfg. Co., Collingdale, Pa.*

Decimal-point Locator and Slide Rule

New "Decl.Point" decimal point locator and slide rule will determine the decimal point mechanically in involved expressions with results up to 19 places. It is said that device so simplifies slide rule calculations that "persons with a very limited mathematical background can evaluate and point

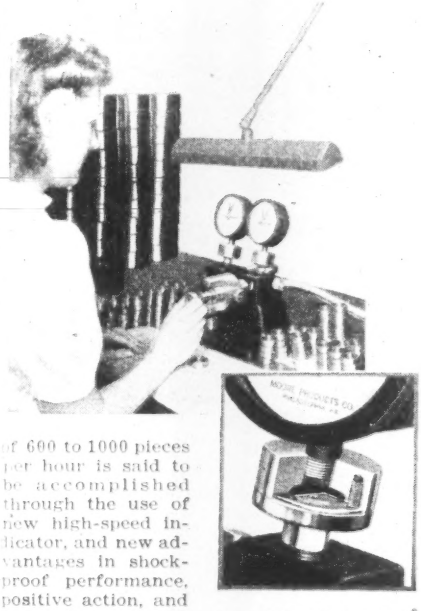
FOUR READINGS WITH ONE SETTING OF HAIRLINE



problems containing cube root, square root, log and trig factors." Functional design of scale arrangements is said to give the computor five advantages over "old style" slide rules: (1) Places decimal point with mechanical accuracy up to 19 places. (2) Gives 30" scale accuracy for cube root. (3) Gives 20" scale accuracy for square root. (4) Synchronized scales permit result, square root, cube root, and log readings to be taken off one setting of hairline. (5) One setting of hairline of "Deci-Point Locator" (which can be used with any slide rule) also determines decimal point location of result, square root, and cube root, up to 19 places. Device is 11" long, 2" wide, 1/8" thick; comes complete in box with coat-pocket carrying case and instruction manual.—*Pickett & Eckel, 58 W. Jackson Blvd., Chicago 4, Illinois.*

Pneumatic-gaging-system Indicator

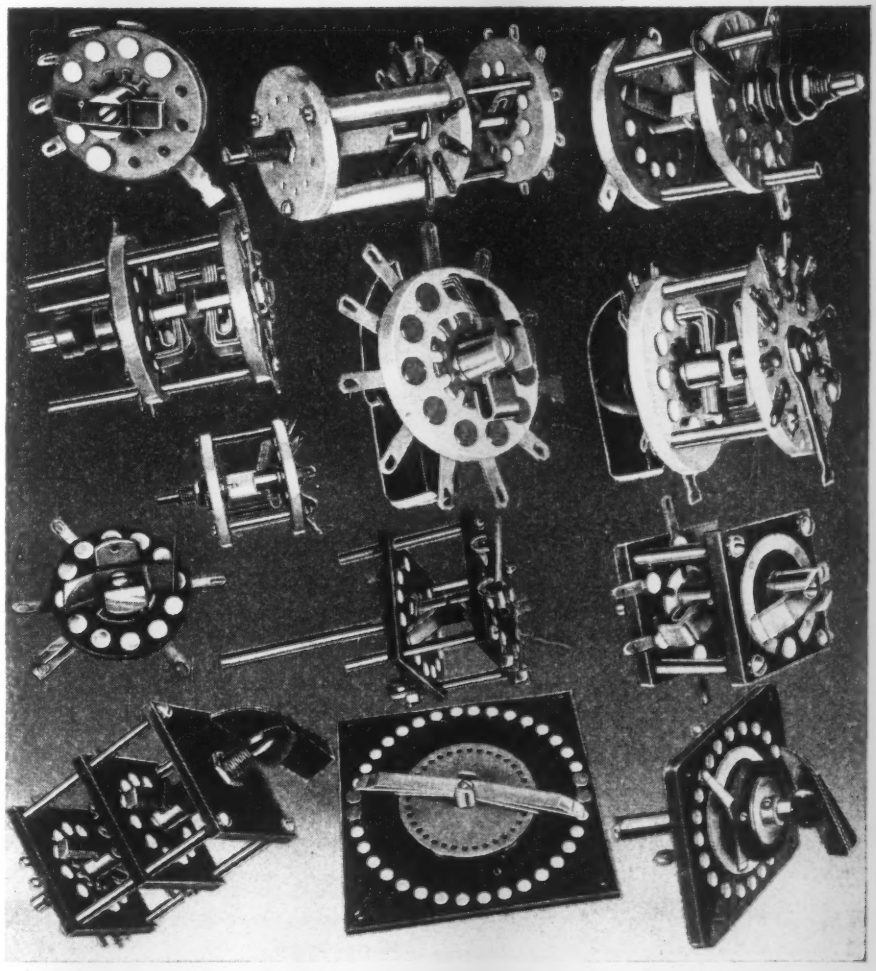
New high-speed indicator is for use with maker's pneumatic comparator gages applied to dimensional inspection to tolerances of 0.0001" or less. Precision gaging at rates



of 600 to 1000 pieces per hour is said to be accomplished through the use of new high-speed indicator, and new advantages in shock-proof performance, positive action, and continuing accuracy are claimed for new design. Indicators have been subjected to as many as 2,500,000 gagings without deviation in the reading. New indicator utilizes a special wide Bourdon tube said to develop from four to five times more pointer torque than indicators previously available. Between indicator and gaging unit is a flexible diaphragm seal. All cavities above diaphragm, including interior of wide Bourdon tube, are liquid-filled. Air pressures that correspond to sizes of workpieces are transmitted through diaphragm, and indicate on dial. Construction is suitable for gaging pressures as high as 35 to 40 lbs./in.². Design also provides a pneumatically-cushioned return action.—*Moore Products Co., H & Lycoming Streets, Philadelphia 24, Pa.*

High-voltage Ceramic Capacitors

Three new types of capacitors, "CRL 855, 854, and 853," are said to be particularly useful in high-frequency power circuits requiring a small capacitance of low loss and stable retrack characteristics. All units have double-cup design to simplify positive attachment of terminal and give maximum flash-over distance between terminals. Plates are pure silver fixed to the ceramic. Standard terminals are silver-plated brass or bronze. Capacitance is determined by area and thickness of ceramic center partition or bottom of cups and by dielectric



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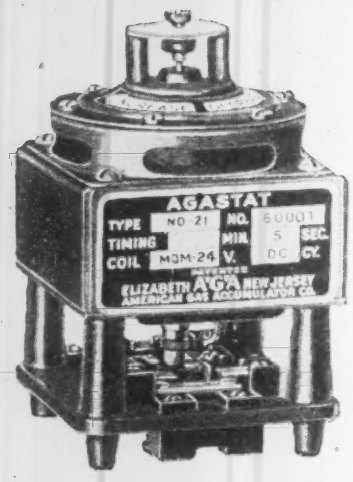

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WHEATSTONE BRIDGE

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Described in Bulletin 100 which also lists National Bureau of Standards and other standards of resistance.

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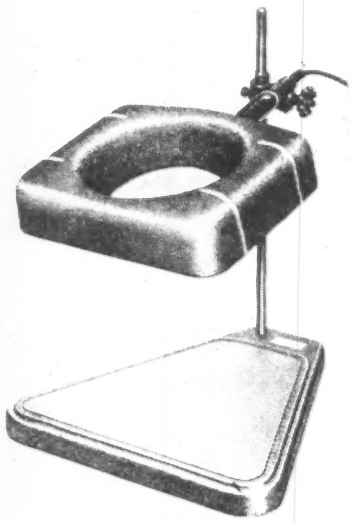
constant of the ceramic. "NPO" units have zero temperature coefficient and maintain a constant capacitance with temperature change. Dielectric constant of this ceramic body is approx. 40. "N750" units have a uniform retraceable change with temperature of 0.00075 mmf/mmf/°C. This ceramic has a dielectric constant of 90 and thus provides more than double the capacitance possible with an "NPO" body of the same size. New capacitors are available with axial screw style and axial lead terminals.—*Centralab Div. of Globe-Union, Inc., Milwaukee, Wis.*

Illuminated Magnifier

New "Model C Magni-Ray" illuminated magnifier has been developed for inspection work where it is necessary to observe a very wide field." It is encased in aluminum alloy casting for ease in carrying it or fastening it to a machine tool. 5" diameter lens, of high-grade optical glass, gives a clear



undistorted view. Housing is fastened to 1" upright by means of a universal clamping device. Triangular 12" × 12" × 12" base is of cast iron. "Model C Magni-Ray" is equipped with two 4" 25-watt tubular bulbs, so silvered so that all light illuminates work; is wired for use on 110-volt a-c. or d-c. supply.—*George Scherr Co., 200 Lafayette St., New York 12, N. Y.*

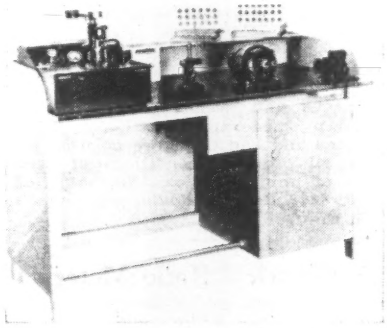
Photoelectric-type Piston-ring Trueness and Gap Gage

New "Electronic Piston Ring Inspector" automatically inspects trueness of periphery and width of gap of a specific size of piston ring. Ring to be checked is inserted inside a master ring of correct dimensional quality

ich is placed on instrument table and ated by a power-driven roller. Gaging ctions are performed by scanning beams light directed onto photocells. One beam light is projected on periphery of piston g, so that any out-of-round condition of piston ring will permit part of light n to fall on photocell. This cell actuates ed rejection signal if piston ring is out-round beyond an acceptable point. Should iphery be within tolerance limits, a green nal will flash on at end of one complete olution if width of gap is also within erance, or a yellow signal will flash if p is undersize. (Beam of light is inter-ted by a mechanical shutter arrangement en gap is passing this point.) Another am of light scans width of gap, photocell ng set to actuate a yellow signal should p be under-size. A third beam of light ergizes another photocell set to flash red jection signal should width of gap be over-e. Master piston rings of known dimen-nal quality are used in adjusting instru-nt for desired tolerances. Instrument can adapted to various nominal sizes, gaps varying width, and also for variations on lowable out-of-roundness of periphery. It claimed that trueness of periphery can determined within a tolerance of 0.0001". spection cycle per piece is less than 5 conds; production rate is determined by eed at which rings are presented to gage. —*The Sheffield Corporation, Dayton 1, Ohio.*

Aircraft Spark Plug Test Stand

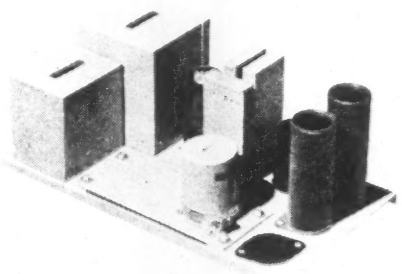
New "Model A660" stand for servicing and testing aviation spark plugs is made in two models. "Model A660W" is equipped with one "BG M-591" Wheatstone bridge



type spark plug tester with bomb and regulator; one electrode adjusting tool; motor for cleaning mica type plugs; heavy duty vise. "Model A660M" is equipped with one BG M-519" Test Bomb with magneto and three-point gap panel; one "BG M-402" electrode adjusting tool; motor for cleaning mica plugs; heavy duty vise. Dimensions: 60" long, 28" wide, 40" high, table top 34" high. Weight: approx. 295 lbs. — *Airplane Mfg. & Supply Corp., Mfg. Div., 6853 Lankershim Blvd., North Hollywood, Calif.* [Corp. requests that inquiries be addressed to *H. H. Mabery, Jr.*, by name.]

Amplifiers

New "102 Series" amplifiers with mounting accessories meet frequency modulation requirements as to frequency response, power output versus distortion, and noise



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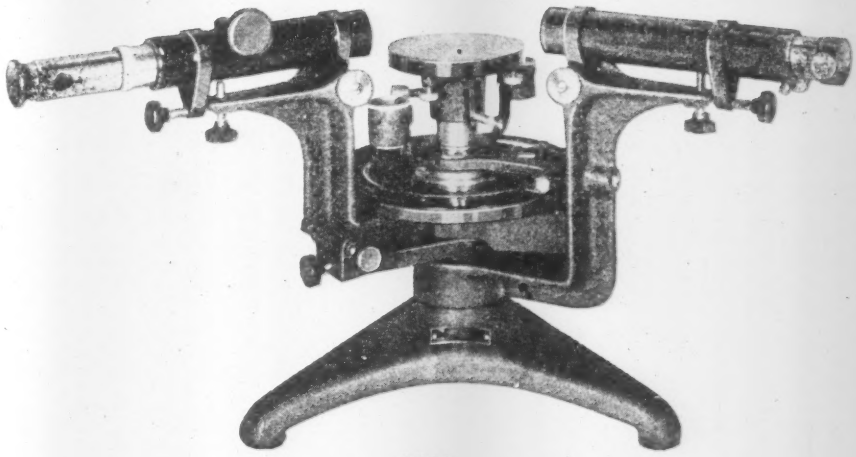

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This instrument incorporates many features found only in the more expensive spectrometers.

Readings can be made to 1 minute; the telescope and collimator have objectives of 25mm aperture and 160mm f.1. The telescope is provided with rack and pinion focusing and 10X Gauss Eyepiece; a bilateral slit with stainless steel jaws 10mm long is provided with the collimator.

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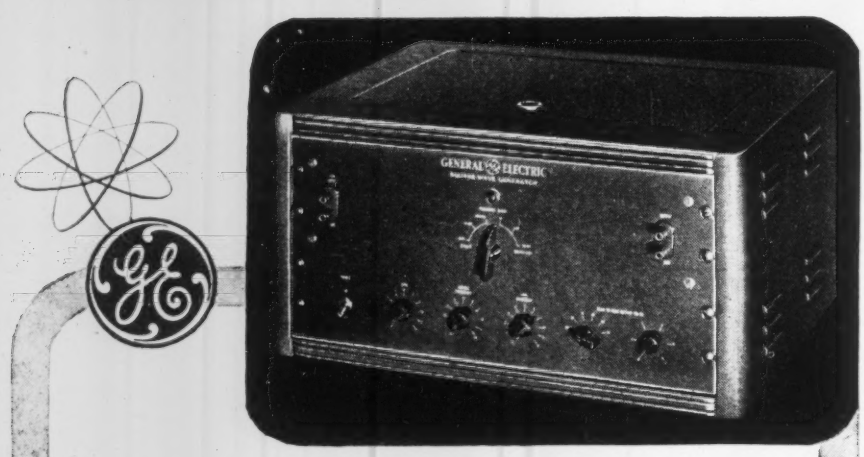

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This unit offers a simple, time-saving, visual picture of performance at the fundamental frequency and at all the significant harmonics contained in a square wave. A single measurement can give as much information as a laboriously plotted point-by-point sine-wave curve with the further advantage that it is instantaneous. The G-E square-wave generator is an indispensable instrument in the fields of radio, television and communications engineering and manufacturing. Write: *Electronics Department, General Electric, Schenectady 5, N. Y.*

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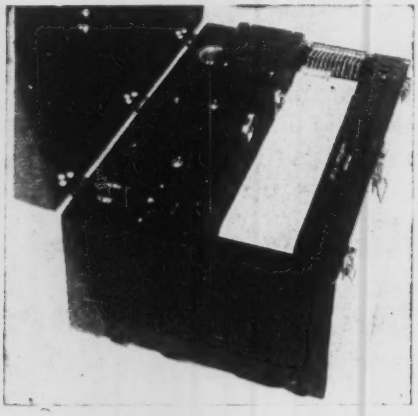

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Through an inertialess electrical recording system, this Garceau Chronograph provides means of measuring without error the length of time an electric current flows. Tape can be withdrawn manually, to allow inspection of recent records, with provision for independently actuated electrical re-wind of used tape.

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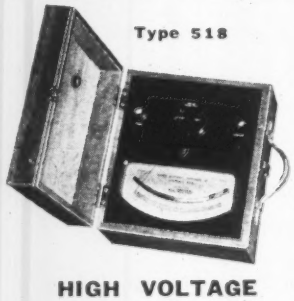

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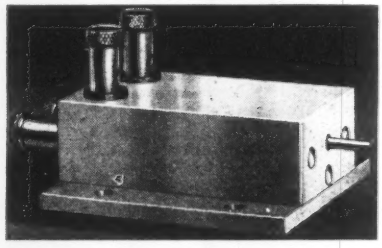
level. They consist of "Type 102-A," with input impedances of 30/250; output impedance 600 ohms; frequency response 30/16000 c.p.s.—0.5 db. "Type 102-B" is a three-stage amplifier with a gain of 95 db. It employs input stage electronic mixing and is intended for high-grade public address installations. "Type 102-C" consists of a three-stage amplifier, fixed gain, adjustable, 75/85/95 db. "Type 102-D" is a two-stage amplifier with input impedance of 600 ohms and bridging; fixed gain 60 db. ohms; input 61 D.B.; bridging input 45 db.—*The Langevin Co., Inc., of 37 West 65th St., New York City.*

Force or Displacement Pick-up

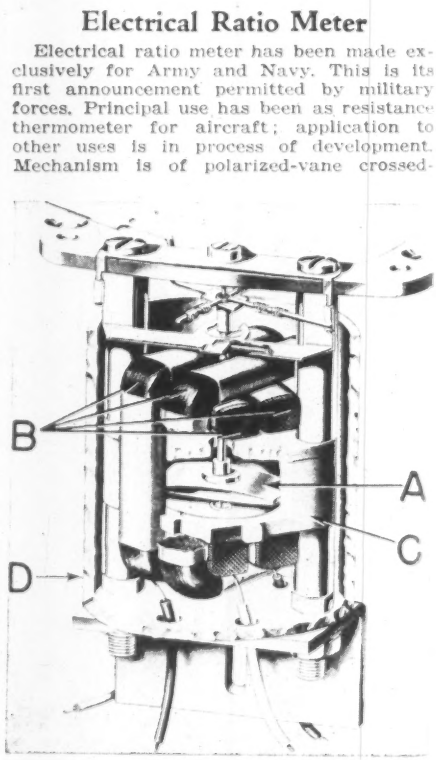
New "Statham Dynamometer-Strain Gage" is designed for measuring minute forces or displacements where only a slight movement is permissible. It is said to be



highly adaptable: as a strain gage its basic range of 0.0015". (total 0.003") may be modified by suitable lever arrangements; and it is capable of measuring forces up to 16 oz. Since it operates electrically, it can be installed to give remote indications or recordings. For these remote-recording applications its accuracy is 1%. Its natural frequency is 1000 c.p.s. Basic unit, in modified forms, can be incorporated into pressure gages and accelerometers. It is not affected by moderate vibration or climatic conditions and can therefore be used under almost all ordinary conditions of service. Weight of unit is 3½ oz.—*Statham Laboratories, 8222 Beverly Boulevard, Los Angeles 36, Calif.*

Electrical Ratio Meter

Electrical ratio meter has been made exclusively for Army and Navy. This is its first announcement permitted by military forces. Principal use has been as resistance thermometer for aircraft; application to other uses is in process of development. Mechanism is of polarized-vane crossed-

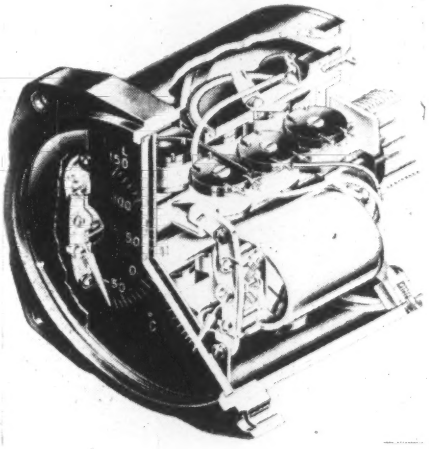


A—moving magnet; B—actuating coils; C—damping housing; D—magnetic shield.

l design, and permits elimination of hair-rings. Construction is exceptionally rugged. Mechanism may be adapted to any service which it is desired to indicate ratio between values of two currents or voltages. Where it is desired to have pointer swing off-scale when instrument is de-energized, a small pull-off magnet is attached to upper ridge for this purpose. Coil resistances up to 1000 ohms are feasible and instrument will operate dependably at currents down to 300 microamperes. Scale span ordinarily covers 120°.—*Instrument Div., Thomas A. Edison, Inc., West Orange, N. J.*

Aircraft Thermometer

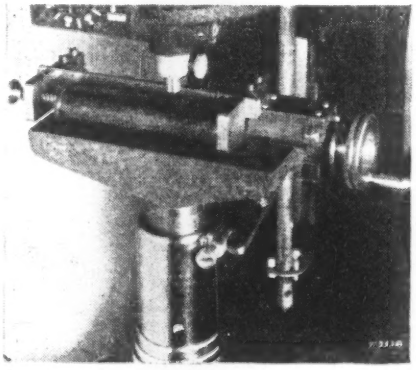
New electrical thermometer indicator for aircraft indicates temperature of oil, coolant, carburetor air, carburetor mixture, or free air. It is also being adapted to elec-

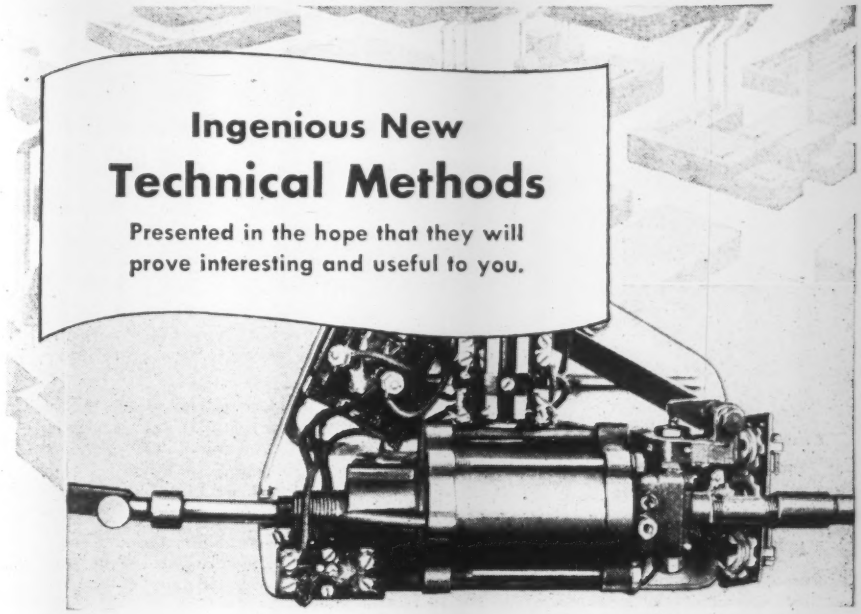


trical pressure indication and other aeronautical uses. Light weight and small size make it possible to incorporate two, three or four movements in a standard aircraft instrument case. Illustration shows a dual unit. Both movements are of ratio type using a small moving permanent magnet, position of which is governed by currents in sets of stationary coils, as described in preceding item. Instrument is said to be almost unaffected by normal variations of battery voltage and, when de-energized, can be arranged to swing off lower end of scale. A small built-in rheostat provides a simple and convenient means of recalibration after overhaul. — *Instrument Div., Thomas A. Edison, Inc., West Orange, N. J.*

Indexing Fixture for Hardenability Test

New Indexing Fixture for Jominy Hardenability Bars was developed in co-operation with J. T. Fergusson of the Notre Dame University, mounts readily on either Clark or Wilson Hardness Testing Machine. It consists mainly of a heavy rigid base casting, indexing screw and a quick-return mechanism. Plug which supports fixture in hardness tester is hardened and ground





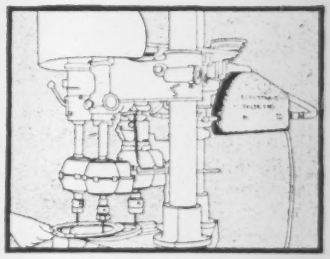
New Electroaire Power Unit Converts Standard Drill Press to Automatic

This exact control over feed and retraction speeds permits ready conversion of a standard drill press with tapping head into an automatic tapping machine, capable of producing Class III threads, even with comparatively unskilled operators. By adjusting speed to conform to the lead pitch of the threads being tapped, the tap will cut without forcing threads, and on the reverse the tap will actually "float" out of the part with no strain against the thread angle.

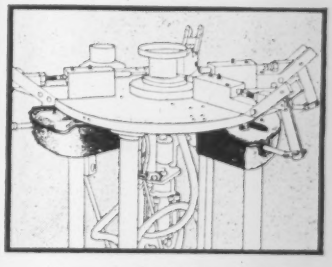
Air-powered jigs and fixtures can be opened, closed, and indexed by the Electroaire Power Feed. The unit can be set for a pre-determined number of cycles so that multiple holes can be drilled in the same piece without ejection, by means of an indexing fixture controlled and synchronized by the Electroaire Unit. One operator can run as many as two or three drill presses, turning out top-quality work with few rejects and with a minimum of tool breakage, thus effecting a great savings in time.

Present stockpiles of finest quality materials used in the manufacture of Wrigley's Spearmint chewing gum are now exhausted—necessitating discontinuance of production. When a supply of proven materials—known to be up to the finest standards of quality—is again available, Wrigley's will resume production—And Wrigley's Spearmint will be back to again help you on your job. In the meantime they are manufacturing a war brand. Wholesome but not excellent enough for the Wrigley brand name.

You can get complete information from Electrolin. Manufacturing Company, 1975 East 61st Street, Cleveland 3, Ohio



Set up to punch 3 holes simultaneously



Shows holes being drilled automatically

Z-55

To the Engineer, Physicist or Chemist Who Seeks A PERMANENT JOB

IF YOU are an engineer, physicist, or chemist now working for a company whose war contracts are terminating there may be a permanent job for you with one of the leading instrument manufacturers. Most of these companies are still working full time on war work. As soon as their war contracts are completed, postwar projects will be ready for action with plenty of opportunity for creative development work. Interested? Write Employment Service, Instruments Publishing Company, 1117 Wolfendale St., Pittsburgh 12, Pa., giving complete professional and personal data. U.S.E.S. consent and release statement will be required.

This is not the advertisement of any manufacturer but a notice from The Instruments Publishing Company as a service to its readers. Names will be made available to prospective employers. There will be no charge to applicants or to prospective employers.

A New

Miniature Electric Indicating Dynamometer-Strain Gage

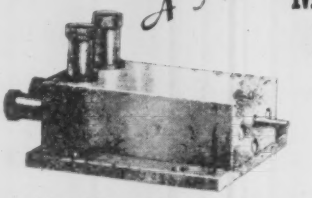


Illustration approximately one-half size

• • • for measuring minute forces up to 1 pound or displacements up to .003 inch without amplification or elaborate power supply.

The new Statham Dynamometer-Strain Gage is a highly adaptable instrument for measuring minute forces or displacements where only a slight movement is permissible.

As a Dynamometer it measures forces up to one pound with a displacement of .0015 inches. Larger or smaller forces can be measured by providing special mountings. As a Strain Gage its basic range of ± .0015 inches may be modified by suitable lever arrangements.

As the Statham Dynamometer-Strain Gage operates electrically, it can be installed to give remote indications or recordings with an accuracy of 1%.

This instrument, in modified forms, has been incorporated into pressure gages and accelerometers. It is not affected by moderate vibration or climatic conditions, and can therefore be used under almost all ordinary conditions of service.

Tell us your problem and let us show how this unit can serve your needs.

Specifications

Range:
Force ± 1 pound
Displacement ± .0015 inch

Power requirement: 9 volts at 50 milliamperes D. C.

Output: Sufficient for a panel microammeter or recording oscillograph

Natural frequency: 1000 cycles per second

Weight: 3½ ounces

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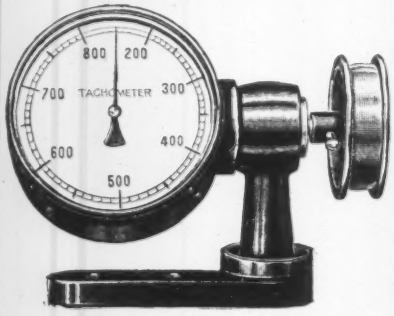

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tool steel, projects upwards through ba casting, and forms surface against whi diamond point presses against the Jomi bar. Screw operating carriage back a forth is stainless steel and turned by mea of a brass chrome-plated hand wheel. bronze half-nut is fastened to a quick-r lease lever engaging the screw. When t bar has reached the end of its travel, ha nut is released and entire carriage slid back rapidly to new starting position. A adjustable stop automatically provides i tial starting point on test bar. A spri plunger holds test bar into position a allows enough freedom for bar to rest firm on hardened steel stud. Finished in bla Kem-Resist, with plated parts finished chrome.—*Precision Scientific Co., 1750 Springfield Ave., Chicago 47, Illinois.*

Thermoscopic Materials

Announcement is made of availability "Tempil°" products for wider range of te peratures: from 125°F. to 1600°F. All a characterized by "sharp and rapid meltin

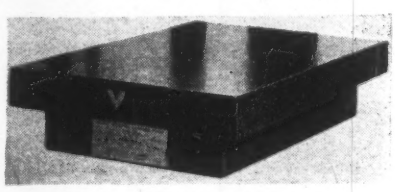
action" at a given temperature. Three forms are available: (1) "Tempilstik°" in 25° intervals to 350°F. and in 50° intervals to 900°F.; (2) "Tempil°" pellets and (3) "Tempilaq°" both in 25°F. —*Tempil° Corp., 132 West 22nd St., New York 11, N. Y.*

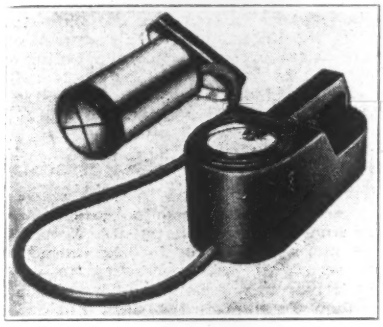
4000-volt Dielectric Test Set

New "Model 1031-R" Dielectric Test Set is particularly applicable to flash and breakdown testing of capacitors, is provided with a built-in high-voltage cut-off relay which operates in conjunction with a remote-control switch to apply test potential only while the remote switch is closed. Additional feature is provision for automatically discharging capacitive test specimens through a bleeder resistor when the remote switch is released. New test set delivers up to 4000 volts d-c., continuously adjustable by means of a primary Variac. An output indicator shows voltage being applied to the specimen.—*Technical Apparatus Co., 1171 Tremont St., Boston, Mass.*

Granite Surface Plates

New "Velsey" surface plates are made of "black diamond granite" which cannot be warped or otherwise distorted by any conditions to which a surface plate is subjected. Plates are lapped in series to a tolerance of 0.00005" surface flatness. Material is harder than tool steel; consequently cannot be scratched by instruments. Even if nicked by a heavy blow, adjacent material would not be upset, it is said. Material does not corrode, oxidize, abrade, or warp. Because black granite is obtainable in great





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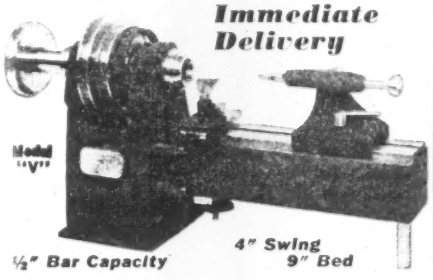

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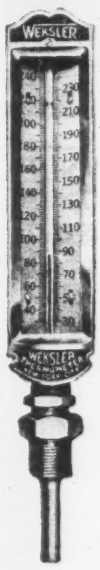

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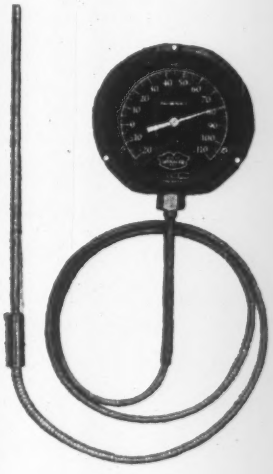
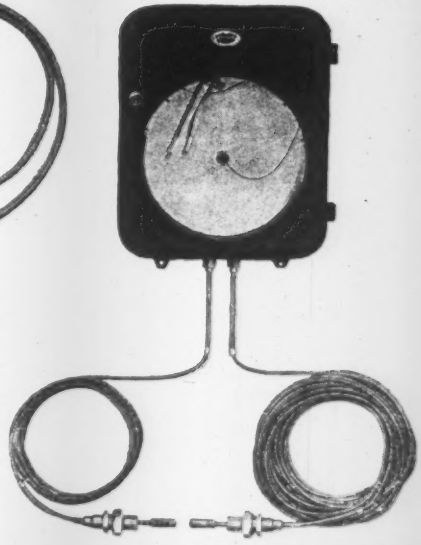
INSTRUMENTS are playing an important role in today's tremendous industrial development—especially where complicated physical or chemical processes are involved. We are proud that WEKSLER instruments—because of their known rugged construction and lasting accuracy—have been chosen for so many of these industrial applications. There is a WEKSLER instrument for every industrial need!



Industrial Type Thermometers have a "V" shape bronze case, removable glass front, red reading or yellow back tube, and may be had with any desired stem.

Dial Indicating Thermometers in a phenol condensate case, with a 4½", 6" or 8½" dial, are mercury, vapor or gas actuated.



Recording Thermometers (one or multiple pen) are in a sturdy, cast aluminum case. Chart size: 10" or 12". Hand wound or electric clock. Mercury or vapor actuated.

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Write to Post-War Products Service, Instruments Publishing Company, Pittsburgh 12, Penna., giving a brief description of your idea, so that this Service may refer it to the interested companies.

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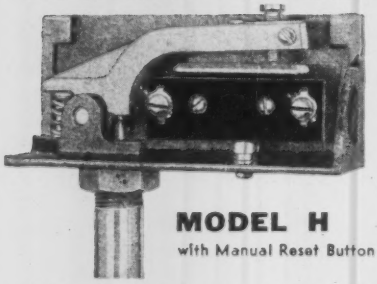

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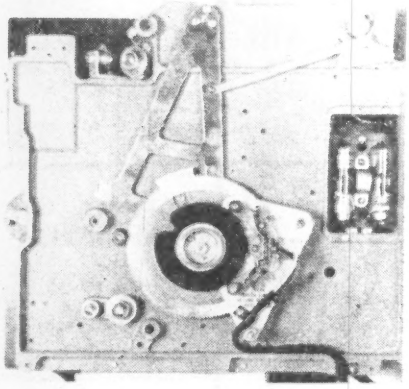
blocks, surface plates can be fabricated from it in largest practicable dimensions. Regular sizes of Velsey Surface Plates are 12" × 18", 18" × 24" and 24" × 36". Special sizes are made to order.—*State Mfg. & Construction Co., Franklin, Ohio.*

Redesigned Built-in Thermostat

New design feature on "SK" thermostats and thermal timers permits more positive, closer and quicker adjustments. Previously a lock nut was used for locking the adjustment screw. It was necessary to use a screw driver in one hand and a wrench in the other. In new design, lock nut is not necessary: adjustment screw passes through two collinear tapped holes on a U-bent bracket. U bend of bracket imparts a strong spring action on thread of adjustment and prevents its turning by any but manual means. It affords closer adjustment, locks the screw more conveniently than a lock nut and insures against loosening due to vibration.—*George Ulanet Co., 88 East Kinney St., Newark 5, N. J.*

Electric-contact Type Control Feature for Recorders

New electric-contact control mechanisms are introduced as a part of circular-chart "Electronik" potentiometer (see *Instruments*, July 1941, page 204). This recorder operates on continuous balance principle. By utilizing the same motion which rebalances the measuring circuit to actuate a control switch, there is no delay between rebalancing and control-switch actuation, which is said to be practically simultaneous

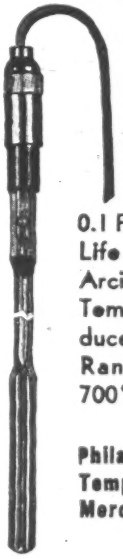


with change in temperature. Illustration shows rear view of instrument chassis; front view of recorder-controller is similar to that of recorder in our July '41 issue.

"Model 70" with relay is available on both standard-speed and fast-speed instruments. Open contact control switch, mounted on rear of instrument chassis, operates locking-in type relay mounted in instrument case. Power contacts of relay govern external control equipment. Switch contacts are of specially selected metals and operate on low voltage. Control switch is cam-actuated. Cam is securely locked to main operating shaft, assuring no lost motion between slidewire contact, pen and pointer, and control cam. Low-voltage locking-in type M-H relay is mounted in rear of case. Relay coil and control switch circuit operate on 20 volts a.c. Relay contains a built-in transformer to reduce line voltage to 20 volts. Relay power contacts are s-p.d-t. for on-off or two contact control action. Relay contact rating (non-inductive loading) is 10 amps. at 115 volts a.c; 5 amps. at 230 volts a.c. ½ amp. at 115 volts d.c.; ¼ amp. at 230 volts d.c. Power to relay transformer is supplied through main instrument power switch. When instrument power is shut off relay will drop out, simulating high temperature, and shut down control equipment.

"Model 71" without relay: Open contact control switch mounted on rear of instrument chassis provides direct operation of

Philadelphia Merc-to-Merc Thermo-Regulators Feature



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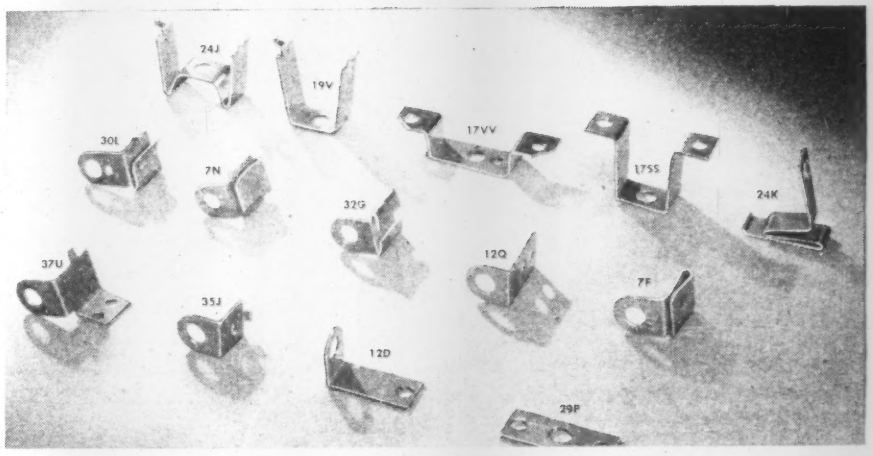

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external control equipment. Control switch actuation is the same as with relay. Instrument power circuit and control circuit are interconnected internally. Controlled equipment must have same voltage and frequency rating as potentiometer controller. Both sides of line are accessible in rear of case for making external control connections. Switch is factory-adjusted for low-high control action; can be adjusted in the field to provide low-neutral-high control action. Control point setting and control index are same as with relay. This controller is available in same voltage and frequency combinations as the circular chart recorder.

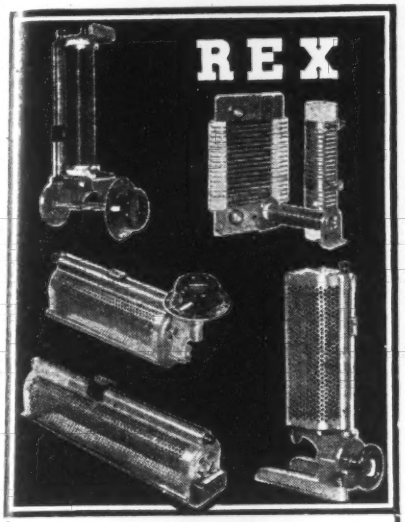
Pneumatic controller with auxiliary switch is a standard circular chart potentiometer pneumatic controller in a standard case. Auxiliary switch is cam actuated, cam being securely locked to main operating shaft, assuring no lost motion between slide-wire contact, pen and pointer, and control cam. Contact capacity of auxiliary switch is 1 amp. at 115 volts a.c. (non-inductive load). Instrument power circuit and auxiliary switch circuit are inter-connected internally (see above). Auxiliary switch operating point and pneumatic control point are separately and independently adjustable. To avoid confusion with pneumatic control point index setting, no index is provided to indicate setting of auxiliary switch. This controller is available in same voltage and frequency as circular chart pneumatic controllers. — *Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Penna.*

Laboratory and Tool-room Furnace

Newly re-designed "Type MLR" electrically-heated furnace, for laboratory and tool room, is now supplied with full metal outer casing, made of reinforced steel and layered insulation. Furnaces are available in standard sizes for operation up to 2000°F and equipped with patented "folded and formed" production furnace type heating elements.—*Harold E. Trent Co., 247 Leverington Avenue, Philadelphia 27, Pa.*

Electrical Instruments

New line of instruments known as "GEM" is announced. Units are said to be designed "for accurate measurement of current wherever current is to be measured." Among features are linear scales, unit construction, and dust-proof cases. Unit construction, which makes inspection and servicing quick and simple and largely eliminates necessity of recalibration, consists in assembly of jewel bearings, armature and core as a unit that maintains accurate alignment and permits almost instant removal. Another unit consists of Alnico magnet and pole-piece brazed together to attain greater rigidity. Brazing is done in an induction furnace to assure uniform joint and prevent spreading or loosening under vibrations. Alnico magnet, with extremely high energy per unit volume, permits smaller size and lighter weight: entire instrument weighs 0.5 lb. Greater density of magnetic field permits use of lighter moving elements in microammeters and low-range milliammeters, thus prolonging jewel and pivot life. In order to maintain an even flux across air gap, unit movement is positively mounted on magnetic unit. This makes possible a linear scale. Equal divisions of this scale make "GEM" instruments particularly adaptable to special jobs with multiple scales such as "kit meters." Manufacturer has also announced a policy of custom-designing instruments to fit individual needs. "GEM" standard instruments come in a wide range of models but where standard models cannot be adapted to do the job a special model will be designed. Standard "GEM" instruments include d-c. voltmeters, ammeters, milliammeters, microammeters, and radio-frequency ammeters of the a-c. thermocouple type. — *General Electronic Manufacturing Company, Culver City, Calif.*



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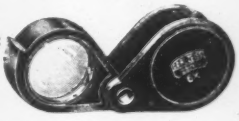

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INSTRUMENT SOCIETIES CALENDAR

City, Society and Secretary			Date	Place	Subject	Speaker
Atlanta, Georgia	Georgia Society for Measurement & Control	Robert E. Gemmert, P.O. Box 1714, Atlanta				
Baltimore, Maryland	Baltimore Industrial Instrumentation Society	J. J. Seglets, 35 S. Potomac St., Baltimore 24		Engineers Club, 6 W. Fayette St., Balto.		
Chicago, Illinois	Chicago Society for Measurement & Control	A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago	Mar. 5(B)	M&M Club, 237 Merchandise Mart	"Improve the Controlled Process!"	J. G. Ziegler, Taylor Instrument Companies
Cleveland, Ohio	Cleveland Instrumentation Society	W. A. Stubblefield, 2085 W. 104th St., Cleveland 2	Feb. 28(B)	Cleveland Engineering Society	Gyroscopes and Allied Instruments	Walter Buhl, Jack & Heintz Co.
Fort Worth, Texas	Fort Worth Electronics Club	Ralph Ely, 1116 E. Arlington, Fort Worth	Feb 15(A)	Texas Hotel, Fort Worth	Commercial Rectifiers	O. N. Yeary, Texas Electric Service Co.
Gulf Coast (Texas)	Gulf Coast Instrument Maintenance Men's Ass'n	T. H. Pierson, 3030 Roberts St., Beaumont, Texas				
Hartford, Conn.	Hartford Society for Measurement & Control	S. J. Zelle, Bridgeport Thermostat Co., 1225 Connecticut Ave., Bridgeport, Conn.	Mar. 20(B) May 15(B)	Bond Hotel Bond Hotel	Electronics, Fad or Servant Automatic Temperature Control	Dr. Paul G. Weiller C. O. Fairchild, C. J. Tagliabue Div.
Kansas City, Missouri	KC Industrial Instrumentation Society	Gordon H. Burke, 1527 Broadway, Kansas City, Mo.	Feb. 27(B)	Bluebird Cafeteria	pH Measurement and Control	Dr. W. N. Greer, Leeds & Northup Co.
Los Angeles, Calif.	California Instrument Society	Wm. Warren, 842 Adelaide Drive, Pasadena 4, Calif.				
Newark, N. J.	Society for Measurement & Control (New Jersey)	Robt. H. Gray, 1 Whippoorwill Way, Mountainside, N.J.	Mar. 6(B)	Essex House	Design Fundamentals of Industrial Instruments	Louis Gess, Brown Instrument Co.
New York, N. Y.	New York Society for Measurement & Control	H. R. Kalbfleisch, 144-35 No. Blvd., Flushing, N. Y.		Columbia U. Men's Faculty Club, 400 W. 117th St.		
N. Indiana	Northern Indiana Soc. for Measurement & Control	K. M. Frame, 25 Ruth St. Hammond, Indiana				
Philadelphia, Pa.	Philadelphia Society for Instrumentation	G. E. Gress, c/o ATC, 34 E. Logan St., Philadelphia	Feb. 21(B)	Engineers Club, 1317 Spruce St.	Liquid Level Control	P. Elfers, Fisher Gov't
Pittsburgh, Pa.	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St., Pittsburgh 13	Feb. 26(B) Mar. 26(B) Apr. 23(B) May 28(B)	Roosevelt Hotel Roosevelt Hotel Roosevelt Hotel Roosevelt Hotel	Inter-connected Controls Combustion Control Surface Finish Instruments Process Control	J. Pelletere, Gulf Oil Co W. Pray, Askania Reg. W. Mikelson, G.E. W. B. Heinz, Cochrane
St. Louis, Mo.	St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co., Venice, Ill.				
Toronto, Ontario	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co.	Feb. 15(B)	Diana Sweets, 188 Bloor St. W., Toronto	Selection of Temperature Control Equipment	J. M. Jackson, Leeds & Northrup Co.
Washington, D. C.	Instrument Society of Washington	W. A. Wildhack, 328 N. Oxford St., Arlington, Va.	Feb. 21(D)	Interior Dep't Auditorium	Electric Relays	L. F. Crabtree, Automatic Electric Co.
Wyandotte, Mich.	Instrument Society of Wayne County	D. J. McCloskey, 116 Oak St., Wyandotte, Mich.	Feb. 26(B)	West Mound Methodist Church	Askania Controls	H. E. Early

(A) Meeting at 7:30, no dinner (B) Dinner at 6:30, meeting at 8 (C) Dinner at 7, meeting at 8 (D) Meeting at 8, no dinner

CHICAGO

At the January meeting of the Chicago Society for Measurement & Control, Mr. Perry A. Borden, of The Bristol Company, spoke on "Telemetering." He defined telemetering as the "science of obtaining, at a convenient location, a measurement from a remote point," and pointed out that telemetering is often used as a means of totalizing two or more measured quantities.

Mr. Borden mentioned that the science of telemetering dates back some 50 or 60 years, but the first well-known article on the subject was written by Mr. O. J. Bliss of the Commonwealth Edison Co. in Chicago. In that article, Mr. Bliss described the telemetering system devised and used by his organization. In 1931 the A.I.E.E. undertook the task of compiling data on telemetering methods and in 1932 the Committee submitted their report. This report was revised in 1934, at which time it contained the descriptions of some 70 different systems. In 1941 the A.I.E.E. prepared a new up-to-date article which is available from the Society and is entitled "1941 Report on Telemetering and Supervisory Control."

Following his preliminary remarks, Mr. Borden commented on various illustrative slides showing the various types of telemetering systems which he had divided into five different classifications: Frequency, Position, Current, Voltage, and Impulse. He pointed out that of the 70 old telemetering systems, about 50 different methods still exist and described several representative present-day methods under each of the above classifications. In his concluding remarks, he mentioned the use of telemetering systems in the recording and control of pressures, levels and flows, as well as the totalizing of circuits and power loads.

Following the presentation of the paper, those present had the opportunity of examining various metering units which Mr. Borden had brought for demonstration purposes. These units were shown in actual operation.

Those interested in telemetering systems found in Mr. Borden's paper basic information on all the prominent present-day systems presented in a concise and understandable form. The Society is indebted to Mr. Borden and his Company for a most interesting meeting.—G. R. THOMASON.

KANSAS CITY

At the December 19 meeting of the Kansas City Industrial Instrumentation Society, new council members were elected as follows: Baker Manley (J. F. Pritchard & Co.); Edwin Thompson (Minneapolis-Honeywell Regulator Co.); Lester Johnson (Sinclair Refining Co.); Lou Mears (Sullivan-Mears Co.); Roy Carns (Sinclair Refining Co.).

The annual financial report was made by our Secretary-Treasurer, Gordon Burke, who reported we were very much "solvent."

In place of our regular Quiz Kids, the first portion of our meeting was thrown open to questions and answers from the floor. Several problems were solved and worthwhile suggestions made on others. For example, George Agin of Sheffield Steel Corp. had a problem wherein dust and moisture were interfering with the accuracy of some radiation pyrometers. It was suggested that neoprene be used as a gasket material. All members agreed that discussions of this type were very much worthwhile.

Our guest speaker, C. E. Defabaugh of Phillips Petroleum Co. presented a real story on his experience with the H. F. Alkylation Units. Charley had a world of practical suggestions for the use of the proper material to be used on the instruments and controls learned from actual operating experience. Some of his suggestions were as follows: Avoid small piping. Avoid screw connections; always use welded or ring joints. Use tricocks to check levels against instruments in indications. Use gate and globe valves. Monel was found best for valve material. Aluminum or copper is best for valve packing. Little valve lubrication is needed. No purge seals are needed on valves. Charley put a lot of fire into his speech and contrary to his little joke, Johnny was wrong when he said Charley did not put enough of his speech in the fire.—W. A. REICHOW.

NEWARK

The Society for Measurement and Control (N.J.) held its first meeting of the year on Tuesday, January 2, at the Essex House in Newark. Mr. D. A. Campbell of the Bryant Heater Co. presented a basic paper on Combustion Protective Devices. He first gave a few examples of events leading to the development of such protective devices about ten years ago. He then reviewed in some detail the basic principle of operation of such equipment known to be commercially available, and analyzed the limitations and the important factors that must be considered in making a proper application of each type. Basic types of flame detectors which were described included, in addition to the simple types, the photoelectric cell, and circuit employing the known high resistance conductance of flames. The latter included both the non-electronic and the electronic type circuits.

Mr. Campbell stressed, with suitable reference to specific installations, the import

...e of correct application and installation, ...d careful maintenance.

The question period indicated that such ...vices are of prime interest to the mem...rship. Mr. Campbell's well-organized ...alysis of this type of equipment is con...ered a basic study.—H. F. MOORE

NEW YORK

About fifty attended the dinner preceding ...e January 30, 1945, meeting of the New ...rk Society for Measurement & Control; ...d ten to fifteen others arrived later for ...e business session and lecture. The annu... reports were presented and accepted and ...e following elected to serve during 1945: *President*, Prof. Carl F. Kayan, Dept. ...f Mech. Eng'g, Columbia University; *Vice-President*, Prof. C. H. Colvin, Guggen...eim School of Aeronautics, New York ...niversity; *Secretary*, H. L. Hildenbrand, The Esterline-Angus Co., Inc.; *Treasurer*, ...E. Corbett, C. J. Tagliabue Div., Portable Products Corp.

Executive Committee, Irving H. Blatz, Bulova Watch Co.; C. D. Corey, Bulova Watch Co.; Harry E. Geddes, American Airlines, Inc.; Robert K. Farnham, Instruments Publishing Co.; H. C. Roters, Fairchild Camera & Instrument Corp.

Until a by-law can be adopted, Mr. Fairchild, who has been President since the beginning of the Society, was asked to consider himself Adviser to the Executive Committee so that the Society will continue to benefit by his ability and experience.

Following the business meeting we heard a talk, illustrated, by Dr. Joseph F. Kubis, Graduate School, Dept. of Psychology, Fordham University, on Recent Developments in the Detection of Deception. Dr. Kubis gave us a short history of lie detection and then described the Fordham Lie Detector. He illustrated his talk with slides showing records obtained in actual criminal cases. —H. L. HILDENBRAND

WASHINGTON

At the January 16th meeting of the Instrument Society of Washington, a Synthetic Sapphire Symposium was attended by nearly two hundred persons.

Arthur K. Seeman, Engineer, Linde Air Products Co., described the manufacture of synthetic sapphire in boules or rods, and reviewed the various uses of this material.

Charles D. Burgess, Chief, Jewel Bearing Section, War Production Board, described the processes and machinery used in the manufacture of synthetic sapphire instrument bearings, and reviewed the history of the government's production program.

William H. Godfrey, Sales Manager, Sapphire Products Division, Elgin National Watch Company, described the application of synthetic sapphire in gages and cited the remarkable record these gages have made in length of trouble-free life.

A lively question period proved the timeliness of the topic. Sample gages, bearings, and other synthetic sapphire products were exhibited after the meeting.—W. A. WILDHACK

WYANDOTTE

The Instrument Society of Wayne County met as scheduled on January 22. There was further discussion on the projected school to be conducted by our more experienced members for the benefit of new instrument men. Our Bookshelf is taking shape. We are listing our books and catalogs and getting ready to place them in the space set aside for us at the Wyandotte Library.

Mr. Barnum of the Brown Instrument Co. gave a reshowing of the Walt Disney films on Fundamentals of Electricity and Elementary Electronics, and slides on the Brown Electronic Potentiometer. Mr. Barnum's talk accompanying the slides and his explanations afterward improved our understanding of the new instrument.

Despite bad roads and bad weather we had a good crowd and got several members.—JOHN MACPHERSON

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Instruments' Book Shelf

EXPERIMENTAL ELECTRONICS. By R. H. MULLER, R. L. GARMAN and M. E. DROZ. Prentice-Hall, Inc., New York, 1942. Cloth, 6 × 9 inches, xv + 330 pages. Price $4.65 (Text Edition $3.50).

It seems rather unusual that a book on electronics should be written by professors of chemistry, and not by physicists or electrical engineers. But the applications of electronics have spread so far, that electronic equipment is frequently used in chemical, biological or other laboratories. The authors seem to appreciate the difficulties confronting workers without special training in the use of such equipment, and have succeeded in writing a unique book which assumes hardly any familiarity with electric circuits on the part of the user. Written more like a laboratory manual, it describes in great detail (sometimes rather too great detail) a large number of standard experiments involving electron tubes of all types.

An extremely important feature of the book—unfortunately absent in many texts—is the indication of the numerical values of resistors, capacitors, etc., on the circuit diagrams or in the text. Likewise useful are numerous graphs showing typical results of the experiments.

All important applications of electronics (excepting communications) are discussed. The first chapter gives a survey of the fundamentals of electric circuits and a description of the most frequently used component parts of electronic equipment. Other chapters deal with different kinds of electronic tubes, including photocells and cathode-ray tubes, and describes experiments showing their characteristics and their typical applications. Further chapters describe standard circuits such as power supplies, amplifiers, oscillators, electronic voltmeters, etc.

While the authors may have gone a little too far in broadness of style and description, they have certainly succeeded in writing a book which will be outstandingly useful not only as a textbook (for which purpose it was apparently intended) but also a practical handbook for the assembly of circuits for special purposes, and even as a guide for trouble-shooting.

—I. ESTERMANN, *Carnegie Institute of Technology, Pittsburgh.*

PRECISION MEASUREMENT IN THE METAL WORKING INDUSTRY—Vol. I. Prepared by Dep't of Education of Internat'l Business Machines Corp. Syracuse University Press, Syracuse, N. Y., 1942. Fabrikoid binder, spiral bound, 8¾ × 11¼ inches, viii + 263 pages. Price $2.75.

This volume is a revision of a portion of the I.B.M. Manual under the name of "Measuring Instruments." It has been used since 1935 as a text book by the International Business Machine Company for instructional purposes within their organization. Since 1940, it has been widely used by the Army Ordnance also for instructional purposes. Having been constantly in use, it has had continuous revision to increase its adaptability in teaching personnel the use and application of precision measuring equipment. This volume contains a short introduction familiarizing the students with principles of precision measurement and the organizations which established these principles. The remainder of the course is developed by breaking down precision measuring equipment into types and classes and dealing with the classes separately as to the principles, background, manufacture, application, use, and care of the instrument. Each chapter is concluded with a group of questions designed to test the students. The questions are simple but thorough and discerning, and each group contains a number of problems. On this basis, Volume I deals with the following subjects: Introduction, Nonprecision Line-graduated Measuring Instruments, Micrometer and Vernier Type Instruments, Precision Gage Blocks, Fixed Gages, Thread Gages, and Dial Gages and Test Indicators.

Because of the way in which it has developed, this book provides a down-to-earth course of instructions in the principles of precision measurement. It is easy to teach and easy to learn.

—R. A. BOWMAN, *Major, Ord. Dept., In Charge of Pittsburgh District Gage Laboratory, A.S.F.*

THE MICROSCOPE AND ITS USE. By FRANK F. MURROZ and H. A. CHARIPPER. Chemical Publishing Company, Inc., Brooklyn, N. Y., 1943. Cloth, 5½ × 8¾ inches, xii + 334 pages. Price $2.50.

Designed primarily as a practical aid for the student and laboratory technician, this little book has much to recommend it to the novice and experienced microscopist alike. All details of optical theory, except those absolutely essential to the everyday use of the microscope, have been eliminated to make way for a series of simple but lucid discussions on the manipulation and applications of the instrument in the several fields where its use has become important. Simplifying rules, tricks, and warnings against common mistakes are given in abundance.

Perhaps the most unusual feature of the book, however, is the style of composition and writing which, though almost as readable as a novel, is so organized as to make easy the finding of specific information.

Emphasis is placed upon the biological microscope and its attendant techniques, especially microtomy. Described in somewhat less detail are the uses of the metallurgical, petrographic, polarizing, binocular, and bullet-comparison microscope as well as of many pieces of accessory equipment. The chapter on "Common Errors in the Use of the Microscope" deserves special mention as does the appended "Glossary" which tends rather more toward a condensed encyclopedia than toward a mere table of definitions. Lest it be inferred that the book as a whole is encyclopedic in nature, however, it is only fair to point out that the specialist in a particular field may well find the subjects of peculiar interest to him treated briefly or not at all. For the most part the less common instruments and techniques have not been mentioned and photomicroscopy is touched upon but lightly.

The illustrations, though numerous, are somewhat disappointing: they appear to have been drawn largely from the sales literature. Nevertheless, this reader, despite almost daily practice in microscopy during most of twenty years, found in the pages of this book many helpful suggestions that had heretofore escaped him—and found it so entertainingly written that it was difficult to view it as the book of reference that it really is.

—FREDERICK N. RHINES, *Carnegie Institute of Technology, Pittsburgh.*

COMPOSITE AIRCRAFT MANUFACTURE AND INSPECTION. By LENO C. MICHELON. Harper & Brothers, New York, 1944. Cloth, 8 × 11 inches, xii + 547 pages. Price $6.00.

In this book Lieutenant Michelon has written what appears at first glance to be an encyclopedia of airplane manufacture. He describes properties, processes of fabrication and methods of inspection of aluminum, magnesium, steel, wood, plastics and fabrics. It is notable, however, that of the approximately 500 pages, more than 120 are devoted to "Wood in Aircraft" and an approximately equal space is allotted to a description of inspection theory, equipment and methods. This is quite a contrast to the twenty-odd pages given to heat treatment of aluminum and steel.

In concentrating on two subjects, Lt. Michelon has made what appears to be a wise choice. Until the outbreak of the present war, wood had almost disappeared from the picture of engineering materials. Certainly, the development of processes for fabrication of durable wood structures had lagged. As a result, wood structure development has almost been a pioneering activity in the past few years, and what little literature there is on that subject is largely out of date. A few of the chapter headings of Part 2, "Wood in Aircraft," indicate the broad scope of this discussion:

V. Characteristics of Aircraft Woods
VI. Kiln Drying and Air Seasoning of Aircraft Lumber
IX. The Manufacture and Inspection of High-density Plywood
X. Radio Frequency and Compregnated Wood.

These and other chapters on use of wood are not a presentation of theory or suggested ideas, but a detailed description of what has proven successful and unsuccessful in aircraft wood construction. It is pointed out that in properly-selected woods, the ratio of weight to strength is equal to that of aluminum, magnesium, steel, and plastics, the other common aircraft materials.

For instrument men, the most interesting and valuable portion of this book will be the six chapters on Dimensional Control and the two on Testing for Physical Properties. These chapters cover the theory, limitations and application of almost every dimensional control device in use today. Beginning with the simple rule, the discussion progresses through verniers, micrometers, ring, plug, and snap gages, indicators, indicator gaging assemblies, and various types of comparators. There has been a great deal of misinformation on this subject and this clear-cut and straightforward discussion of gages and gaging will help to clarify many misconceptions and false ideas.

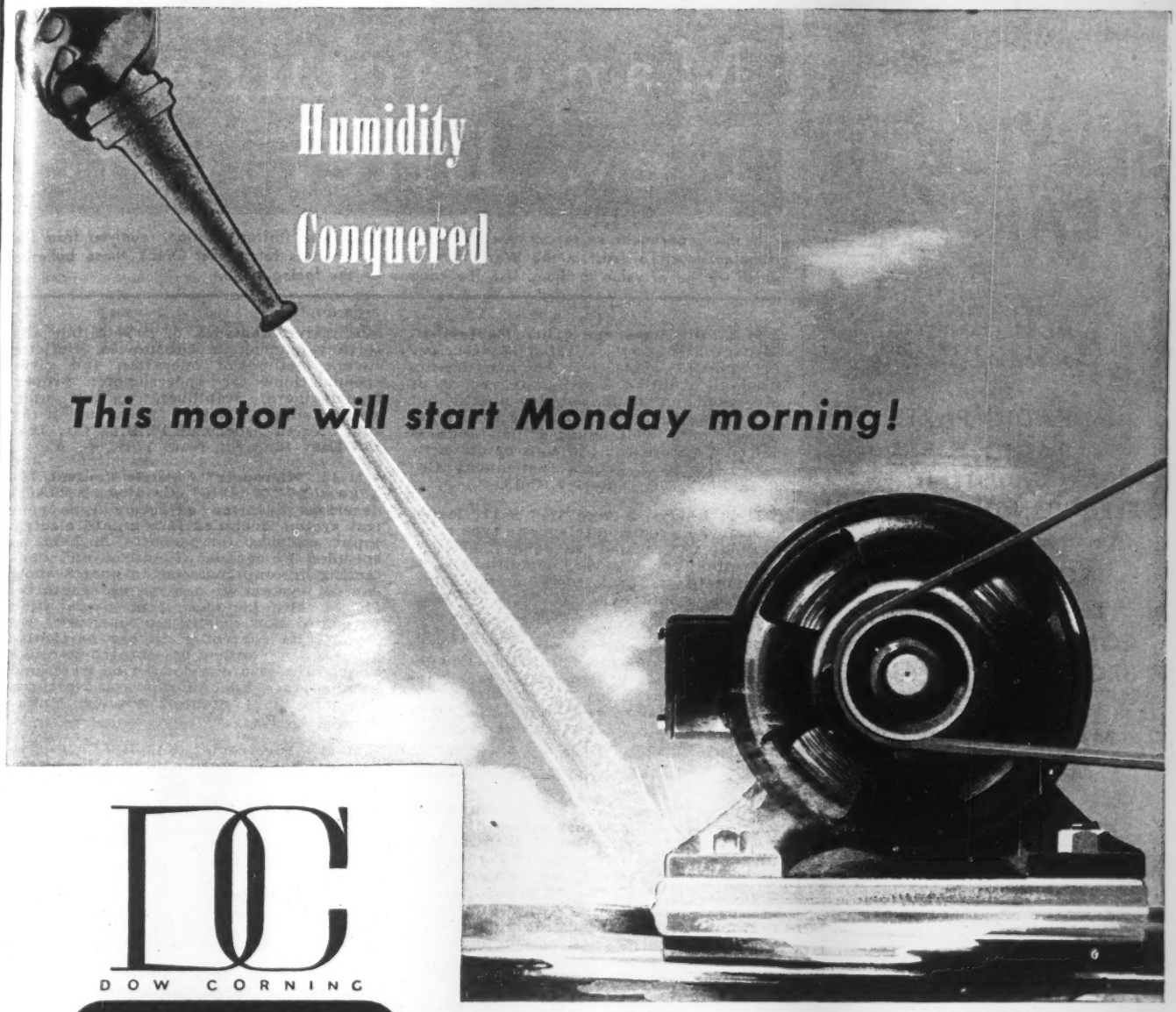
Diagrams and illustrations appear at the end of each chapter. These illustrations depict not only the equipment but procedures in assembly of elements and use of equipment. A clear straightforward style of writing is used throughout. "Composite Aircraft Manufacture and Inspection" can therefore be a very useful guide to both engineers and shop men on many of the phases of aircraft manufacture. At the same time, a broad picture is painted, and much of the material is applicable to other manufacturing processes. Lt. Michelon's book fills a real vacancy in the industrial bookshelf.

—S. H. ISAACS, *Instrument Engineer, Wright Aeronautical Corp., Cincinnati, Ohio.*

ELECTRICAL COUNTING (American Edition). By W. B. LEWIS. Cambridge University Press, Cambridge, England, and MacMillan Co., New York, 1943. Cloth, 5½ × 8½ inches, 144 pages. Price $2.50.

The author describes the methods and circuits used in research work in nuclear physics for the counting of alpha and beta particles. These circuits, however, are suitable for many other purposes, among them the counting of any kind of electrical impulses. They can, therefore, be adapted to industrial counting, traffic counting, etc. Details are given for the construction of amplifiers, stabilizers, and recorders. The circuit diagrams are of large scale and well legible, and all component parts are clearly marked. The designations of the tubes are those used in England, and it would be helpful if the American edition would be supplemented with a chart showing the corresponding American types. Apart from the counting, the book contains several chapters of special interest to nuclear physicists.

—I. ESTERMANN, *Carnegie Institute of Technology, Pittsburgh.*



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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. To assist in the War Effort we urge readers to request ONLY those bulletins which will be of value to them. Use the coupon on the facing page.

M-33 **Oil Well Surveying Equipment.** 20-page 8½" x 11". Catalog 43 describes (1) multiple-shot survey instruments used to make a continuous record of direction and inclination (2) single-shot survey instruments to make a directional survey of a well being drilled and (3) drift indicators for the control of vertical drilling. Eastman Instrument Co., P. O. Box 1500, Denver 1, Colo.

M-34 **Relays.** 2-page 8½" x 11" leaflet describes a precision telephone type relay hermetically sealed to insure efficient operation under severe conditions; and a midget-type relay for communication, electronics and aviation. Betts & Betts, 551 West 52 St., New York 19, N. Y.

M-35 **Vacuum-tube Voltmeter.** 1-page 8½" x 11" catalog sheet illustrates and describes a stable-bridge-circuit type vacuum tube instrument for measuring a-c. and d-c. voltages and ohms. Electronic Mfg. Co., 140 S. Second St., Harrisburg, Pa.

M-36 **"X-ray Diffraction-An Industrial Tool."** 4-page 8½" x 11" reprint of a technical article explains the technique employed for the identification of materials: 1. Establishment of identities in ceramic clays, 2. Checking ingredients of dairy products, 3. Quality tests on soapstone before firing, 4. Determination of covering quality of paint pigments, 5. Differentiation of natural and artificial pearls, 6. Identification of aluminum oxide modifications, 7. Differentiation of inorganic fibers, 8. Metallic deposition in formation of metallic carbides, 9. Determination of character of metallic films. North American Philips Co., Inc., 100 East 42 St., New York, N. Y.

M-37 **"Metricator."** 4-page 8½ × 11" bulletin describes operating principle of an air-operated precision gage which will measure internal and external diameters, tapers, narrow grooves, straightness and concentricity. Built with an amplification of 4000:1 it can measure within 0.000025" without influence of human element. Metrical Laboratories, Inc., 417 Detroit St., Ann Arbor, Michigan.

M-38 **Gages and Dial Indicators.** 56-page 8½ × 11" Catalog No. 53 covers dial and test indicators, indicator attachments, dial micrometers, dial comparators, caliper and cylinder gages, with full-size illustrations and a table that gives range of all dial indicators. Descriptions of dials, bearings, and movements (plain and compound) and complete dimensions are included. New models include several long range indicators and portable types of micrometers. B. C. Ames Co., Waltham, Mass.

M-39 **X-ray Spectrometer.** 2-page 8½ × 11" bulletin describes wide range of applications that can be handled by focusing spectrometer and lists some applications for process control in the paint, chemical, ceramic, rubber and metallurgical fields. Instrument provides new method of making quantitative and qualitative analyses of crystalline and certain amorphous substances. Bulletin covers method of operation and gives specifications for spectrometer proper, transformers, stabilizer, scaling unit, power supply, Geiger unit and x-ray tube. North American Phillips Co., Inc., 100 East 42nd St., New York, N. Y.

M-40 **"Micromax" Electric Control.** 24-page 7¾" × 10½" Catalog N-00A(2) describes duration adjusting type control system designed to regulate electric input so that temperature is held as specified by means of an "on-off" contacting system. Installation photos show control system in use in representative plants. Also included is an explanation to show how easily an operator can "tune" the controller to his particular process by adjusting throttling-range knob, rate of droop-correction knob and impulse rate knob. Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pa.

M-41 **Electronic Supplies.** 40-page 5½" × 8½" booklet entitled "December 1944 Availability List" illustrates and catalogs items available on priority for immediate delivery from stock subject to prior sale. Items listed include tubes, sound systems, x-ray machines, transformers, capacitors, resistors, photo-electric units, timers, relays, electric drills, saws, grinders and other tools. Available to engineers and purchasing agents. Walker-Jimieson, Inc., 311 South Western Avenue, Chicago 12, Ill.

M-42 **Spark Plug Thermocouple.** 4-page 8½" × 11" folder describes a new spark plug gasket thermocouple for accurate indication of cylinder-head temperature. Revere Co., Wallingford, Conn.

M-43 **"Electronic Duo-Stat."** 12-page 8⅜" × 10⅞" Catalog Bulletin No. 396, Edition 1, presents salient features of weather-compensated heat regulator for buildings. Diagrams illustrate its application in buildings using hot-water heating, steam heating or warm-air heating. Other auxiliary equipment used in conjunction with the Duo-Stat such as pneumatic valve, electric motor valve, time switches, radiator and outdoor bulbs are also illustrated. Johnson Service Company, Milwaukee 2, Wis.

M-44 **Water Turbine Flow Meter.** 6-page 8½" × 11" Bulletin No. 420 illustrates Simplex Type MO Meter that indicates, records, and totalizes flow rate through water turbines incorporating the Simplex W-K Principle and W-K Differential Taps. A description of the Simplex Type MAP Manometer for measuring the head quantity relation of the W-K Taps is included. Simplex Valve & Meter Co., 68th & Upland Sts., Philadelphia, Pa.

M-45 **Electrically Operated Switches.** 16-page 8½" × 11" Circular No. 600 describes automatic transfer switches, contactors and relays. Outlines major features of some of the units and emphasizes the mechanically locked

mechanism and the inherent electrical and mechanical interlocking. Operating principles of mechanism are illustrated and explained. Automatic Switch Co., 41 East 11th St., New York, N. Y.

M-46 **Midget Electric Motors.** 2-page 8½" x 11" Bulletin M-1 features 1 3/16" diameter frame permanent magnet type motors. Outline drawings, tables and performance charts are included. Globe Industries, Inc., 125 Sunrise Place, Dayton 7, Ohio.

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M-49 **Resistors.** 8-page bulletin, 8½" x 11" contains illustrations, detailed specifications and price list of lead-lug-and-lead, standard lug, adjustable and ferrule types of wire-wound resistors.—Haines Mfg. Corp., 248 McKibben St., Brooklyn 6, N. Y.

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M-53 **Instrument Knobs, Dials, Pointers, etc.** 16-page 8½" x 11" Catalog 103 covers a large number and variety of molded plastic parts for instruments.—Kurz-Kasch, Inc., 1437 Broadway, Dayton, Ohio.

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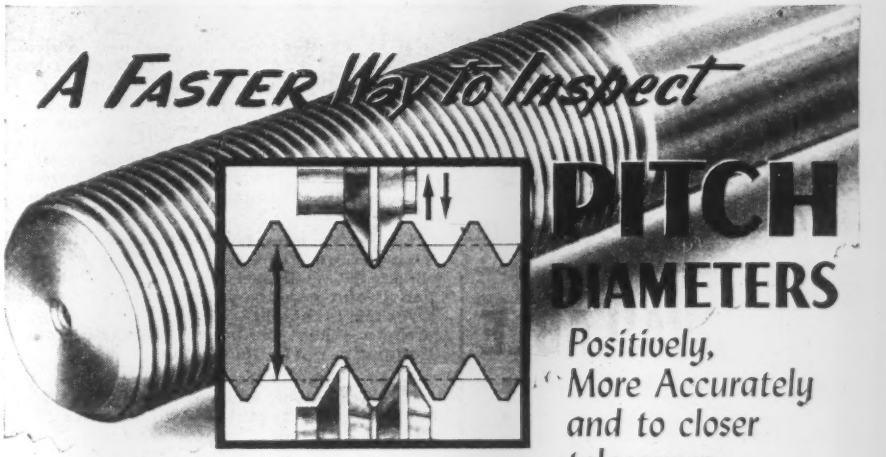

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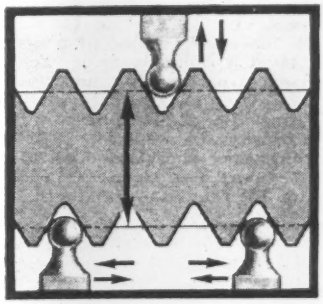

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M-56 **Tachometer Indicator General Test Stand.** One-page 8½" x 11" Data Sheet W-39 illustrates and describes a bench-and-panel equipment for testing aircraft tachometer indicators and generators.—The Standard Electric Time Company, Springfield, Mass.

M-57 **"The CD Capacitor."** The 16-page November issue of this 5¼" x 7½" house organ features two articles: (1) "Phase Inverter Circuits" and (2) "Open Grid Tubes in Low-Level Amplifiers."—Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, New Jersey.

M-58 **Floatless Liquid Level & Industrial Controls.** 28-page 8½" × 11" Catalog No. 145 describes method of controlling liquid level without floats or vacuum tubes; and explains principle and operation of B/W relay. Contains data, pictures of special control panels, application diagrams, motor starters, selector switches, push buttons, special relays and other items. B/W Controller Corp., 2110 East Maple Road, Birmingham, Michigan.

M-59 **Metal Detector.** 2-page 8½" × 11" loose-leaf Page 169 describes an a-c. operated unit which detects presence of metal hidden in non-metallic materials, providing both audible and visible alarms. Illustrated with photographs. General Electric Co., Schenectady, N. Y.

M-60 **Time Schedule Controller.** 8-page 8½" × 11" Bulletin No. 98165 describes how a control schedule is established which requires repetition of a predetermined program involving time coupled with temperature, pressure, flow or liquid level. Shows how auxiliary functions can be synchronized with control of main variable in processing cycle and methods of regulation. Illustrated with photographs showing actual applications as well as cut-away views of instruments. Taylor Instrument Companies, Rochester, New York.

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M-62 **Industrial Electronics.** 40-page 8½" × 11" Publication GEA-4309 contains reprints of eight articles by G. M. Chute published in Steel. These articles cover basic principles of electron tubes, commercial applications and some practical circuits. In addition to discussion of tubes used as rectifiers and amplifiers, author covers electronic control of heat applied by resistance welders, photoelectric relay, stepless control of motor speeds and high-frequency heaters. General Electric Co., Schenectady, N. Y.

M-63 **Automatic Dropping Unit.** Single-sheet 8½" × 11" leaflet pictures and describes dropping unit for determining thickness of cadmium, zinc, copper and tin coatings, using Hull & Strausser method. Unit delivers 100 drops of solution per minute from standard-size bottle. Kocour Co., 4724 S. Christiana Ave., Chicago 32, Illinois.

M-64 **Heating Furnace Control.** 12-page 8½" × 11" Bulletin 122 describes the effects of furnace pressure and atmosphere on economy, quality and scale formation. Illustrated by photographs, schematic diagrams and graphs. Askania Regulator Co., 1603 S. Michigan Ave., Chicago 16, Ill.

M-65 **Optical Projector.** 2-page 9" × 12" circular pictures and describes a projector meeting U. S. Government gage laboratory specifications with 14½" diameter ground glass screen and having magnification lens of 10×, 25×, 50× or 90×. Portman Optical Company, New Rochelle, N. Y.

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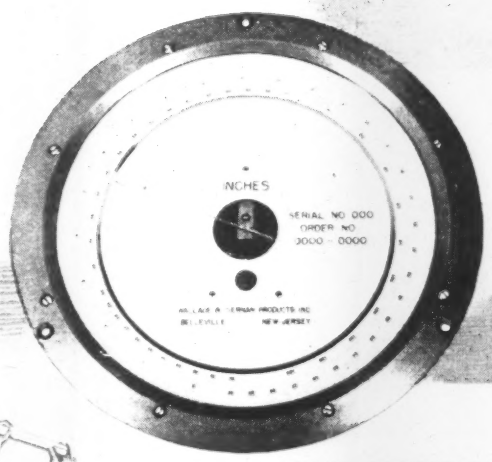

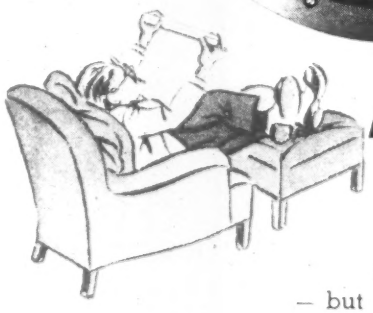

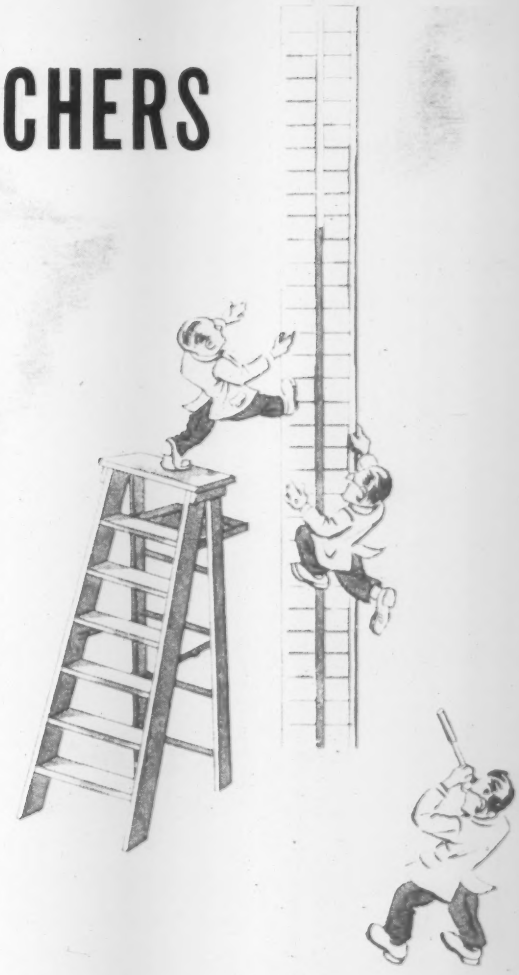

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